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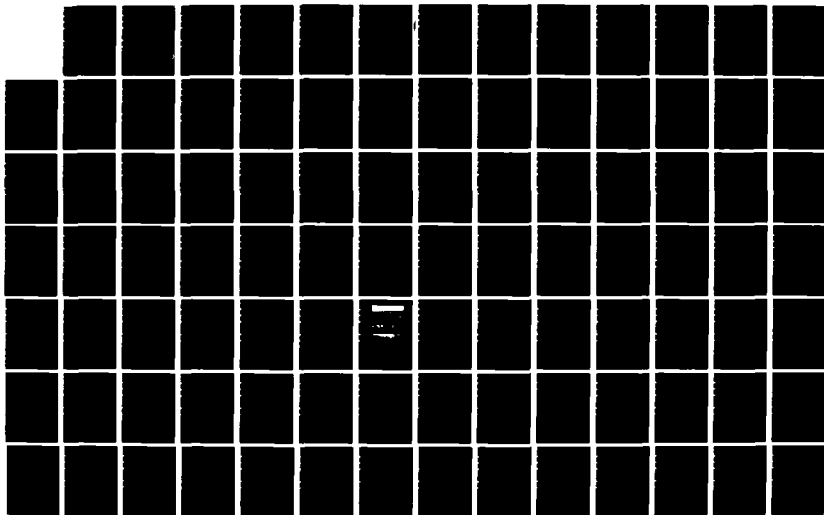
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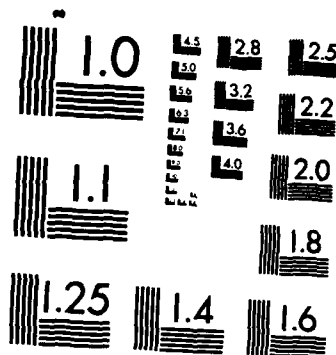
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AN ANALYSIS OF POTENTIAL PREDICTIVE  
PARAMETERS OF MOTION SICKNESS USING  
A COMPUTERIZED BIOPHYSICAL  
DATA ACQUISITION SYSTEM

THESIS

Norman R. Jarvis Charles T. Uyeda, Jr.  
Captain, USAF Captain, USAF

AFIT/GSO/ENG/85D-1

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A COMPUTERIZED BIOPHYSICAL DATA ACQUISITION SYSTEM

THESIS

Presented to the Faculty of the School of Engineering  
of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the  
Requirements for the Degree of

Master of Science in Operations Research

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Norman R. Jarvis, B.S.

Captain, USAF

Charles T. Uyeda, Jr., B.S.

Captain, USAF

December 1985



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## Preface

The goal of this thesis project was to refine and use the computerized biophysical data acquisition system, developed at AFIT by two previous thesis teams, to determine possible predictive physiological parameters of motion sickness. We gratefully acknowledge the invaluable help given by many people in this effort. If anyone is omitted from this list, it is purely an oversight and we apologize. Their help was none-the-less appreciated.

We especially wish to thank Dr. Matthew Kabrisky and Dr. William Czelen, without whose help and constant encouragement this work would not have been possible. We thank our thesis committee and supporters Dr. Joseph Coleman, Dr. Lynn Wolaver, and Dr. Charles Hatsell. A special thanks goes to Dan Zambon for his help with the MASSCOMP MC500 computer system.

We would also like to specially acknowledge the numerous volunteer test subjects who made our work possible. The generous donation of their valuable time and bravado is appreciated more than they will ever know.

Finally, we thank our families and friends for their love and support. Donna, Marissa, Carly, and Brianna, thank you for your love and understanding throughout this AFIT tour; it makes it all worthwhile.

Norm Jarvis and Bud Uyeda

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Abstract

A computerized biophysical data acquisition system was refined and used to collect biophysical data on human volunteer subjects to examine effects of coriolis induced motion sickness. Redesigned sensors to measure electrical cardiac activity, cardiac chest rebound, abdominal/thoracic respiration, peripheral pulse blood volume, facial pulse blood volume, skin temperature, gastric/intestinal activity, nystagmus, and brain wave activity were incorporated with commercially available sensors for galvanic skin response, heart rate, and blood pressure to thoroughly measure the subject's vital signs.

Subjects were rotated in a multi-axis motion chair and data collected for later analysis. Data were collected on paper strip chart recorders in parallel with a MASSCOMP MC500 minicomputer. The MASSCOMP data acquisition system software was refined with better documentation and to allow data replay.



An Analysis of Potential Predictive Parameters  
of Motion Sickness Using a Computerized Biophysical  
Data Acquisition System

I. Introduction

Chapter Overview

This chapter introduces the motion sickness problem and explains why this problem is important. The chapter provides some insight into the reasons for artificially evoking a sensory conflict in humans and how that aids the current study. The specific research problem is stated, and then constrained by the scope, limitations, and assumptions of the research project. Finally, the research methodology is outlined.

Background

Motion sickness is a common illness of great concern to the military. For the common civilian traveler, it is a temporarily distressing, but not necessarily serious, disorder. However, in the military environment, it may be very serious, perhaps even disastrous. Smith (48:162) cites the hypothetical example of a wartime naval combat operation where a high incidence of motion sickness could not only jeopardize a mission, it might lead to capture or death of personnel. Even in peacetime, motion sickness is a significant concern because of wasted time and manpower. The U.S. Air Force is especially interested in recovering resources lost because of motion sickness (35:118). Levy,

Jones, Carlson, and a number of other researchers at the Brooks AFB USAF School of Aerospace Medicine (SAM) are investigating ways to rehabilitate airmen who have been grounded by chronic disabling motion sickness (35:118). The impetus for this effort is the fact that a permanently grounded airman represents a significant financial and trained manpower loss to the Air Force, and causes a feeling of personal failure for the individual. But if the individual can be trained to recognize symptoms of motion sickness and can actively take steps to suppress it, he can remain operationally functional. The training approach used at SAM is to stress an airman close to the point of motion sickness using a rotating chair. The airman is trained to recognize symptoms of the illness, and then he would use biofeedback and relaxation techniques to bring his physiological reactions under control. With gradually increasing levels of stress, and more training, he is able to control his motion sickness in the provocative operational environment. Results of this program have been very encouraging, with 84 percent of the airmen reportedly returned to operational duty (35:121).

Motion sickness is also a major concern in the U.S. space program for both NASA and Department of Defense flights. Concern over space induced motion sickness has been expressed since the beginning of the U.S. space program, but it was not until the middle of the Apollo program that the concern was fully justified (24:1259,1260).

Incidents of space motion sickness suddenly became common in this series of spaceflights and have persisted to the present (25:324). The most plausible reason for the sudden appearance of this malady is the increase in interior volume of later spacecraft and thus greater freedom of movement. Movement, especially of the head, seems to elicit or intensify a motion sickness response (30:513). If this theory is valid, it might predict a large incidence of motion sickness among astronauts flying aboard the relatively spacious space shuttle. Indeed, approximately 50 to 90 percent of the astronauts aboard recent shuttle flights have experienced motion sickness symptoms (30:513). Lackner and Graybiel state the problem succinctly when they say:

On the basis of the first six space shuttle orbital flight test missions, it is clear that space motion sickness is going to be a major concern in the shuttle program. This is especially the case because the shuttle flights will be of relatively short duration, a week or two, and space motion sickness usually is an operational problem only the first 3 or 4 d [days] aloft [31:675].

This problem is considered so serious it prompted Dietlein and Johnston to state that space motion sickness "represents the greatest research challenge facing life scientists in contemporary space medicine and physiology" (10:894).

The real "research challenge" is the fact that despite widespread interest and intense research, little is known about the etiology of motion sickness. NASA recognizes this information void and has organized a broad research program

to investigate four interrelated areas. According to J.L. Homick of the NASA-Johnson Space Center, "These include research on the causes, prediction, prevention, and treatment of space motion sickness" (24:1263).

Determining individual susceptibility under different circumstances and deriving a set of characteristic parameters are the keys to the first stage of the research challenge -- motion sickness prediction. Progress in the area has been slow. Homick states:

Of the various unresolved issues related to space motion sickness, the one which is most perplexing involves the development of predictors of susceptibility. . . . Most past research in this area has yielded results of limited usefulness. Clearly new approaches are required. It would seem that emphasis should be placed on research wherein motion sickness is provoked largely by otolith stimulation and by exposure to conditions which evoke sensory conflict [24:1270].

"Otolith stimulation" refers to structures within the inner ear that, when stimulated by head movement, send neural signals to the brain. These neural signals normally agree with others from the eyes and body. When the signals do not agree, sensory conflict and motion sickness may result. Thus, Homick is saying that sensory conflict should be artificially induced by some type of motion, and the results examined.

An apparatus for evoking sensory conflict in humans and collecting quantified data on motion sickness has been developed and built at the Air Force Institute of Technology (AFIT). This apparatus was built in response to a request from the USAF School of Aerospace Medicine (SAM). In 1982

SAM realized that its motion sickness rehabilitation program was very labor intensive, requiring the services of two flight surgeon psychologists and one biofeedback technician for each training session (35:118). Because of the specialized personnel and equipment involved, the program was restricted to Brooks AFB. To reduce the limitations of the SAM program, Captains Earl and Peterson at AFIT assembled a rotating chair that had previously been used by the Air Force Aerospace Medical Research Laboratory (11). They designed and built a programmable data acquisition system and integrated it with biofeedback equipment, physiological monitoring equipment, and the rotating chair. A subsequent research effort by Captains Fitzpatrick, Rogers, and Williams refined the equipment and automated the data acquisition process with a digital computer (12). The resulting system, which they termed "Computerized Biophysical Data Acquisition System" is well suited for evoking sensory conflict and eliciting a motion sickness response.

#### Problem Statement

To date, research has not quantitatively identified specific physiological criteria as potential predictive parameters of motion sickness in humans. "Physiological criteria" means those processes in a human body that can be measured to establish values for predicting the onset of motion sickness. Those values will be the predictive

parameters. Since the research cannot examine all possible physiological processes, a set will be chosen as the most likely predictors. This set, based on a review of the literature and discussions with current researchers, will include the following: electro-cardiac activity, force of heart rebound, heart rate, peripheral pulse blood volume (perfusion), facial pulse blood volume (pallor), skin temperature, galvanic skin response, muscle tension, stomach motility, intestinal tone, rapid eye motion (nystagmus), respiration rate, and respiration type (thoracic/abdominal), and brain waves (electroencephalograms). These physiological criteria have not been measured and statistically evaluated under controlled conditions to determine their potential for predicting motion sickness in humans.

Specific problems of motion sickness prediction include the following:

1. What are the normal values for the criteria listed above?
2. Using non-invasive techniques, how can these criteria best be measured?
3. Can sensory conflict be artificially induced using the Computerized Biophysical Data Acquisition System described in the thesis report of Captains Fitzpatrick, Rogers, and Williams (12)?
4. Do the physiological criteria listed above change in response to artificially induced sensory conflict, and if so, how?
5. If the criteria change in response to sensory conflict, are the changes statistically significant?
6. What are the change relationships, if any, between the physiological criteria?

7. Can a pattern of physiological criteria changes be correlated, using statistical analysis, to the onset of motion sickness?
8. If a pattern is identified, is it similar among different test subjects or are there different patterns?
9. If there are different patterns of physiological change, can they be cataloged into identifiable groups or types?
10. If specific physiological changes are identified for an individual, are the same changes evidenced on repeat trials or do they differ?

#### SCOPE AND LIMITATIONS

This research investigated the hypothesized relationships between the onset of motion sickness symptomatology and specific measurable physiological criteria. It did not attempt to determine the etiology of the illness or develop a treatment scheme.

The scope of the study was limited to:

1. Refining the data acquisition software system to:
  - A. fully document the software to simplify later changes;
  - B. improve interactive communications for easier use by the non-computer technical user;
  - C. allow for data replay.
2. Development of experimental procedures to include production of a system users guide.
3. Collection of biophysical data from human volunteers.
4. Incorporation of a parallel paper strip-chart recording system for real-time hardcopy output.
5. Initial data analysis for subsequent system refinement and in-depth statistical analysis.

Since the best predictors of motion sickness have yet

to be determined, no attempt was made in this study to use biofeedback techniques.

#### ASSUMPTIONS

The basic premise of this research is that motion sickness is a physiological response to a disturbing influence or influences and it is evidenced by measurable changes in certain bodily processes. The bodily processes may change in particular patterns that may be recognized and used to predict future episodes of the illness. The eventual thrust of this research is aimed at using these predictive parameters to counter the sickness by means of biofeedback control of the physiological responses.

#### METHODOLOGY

The overall approach used to answer the problem posed above was scientific experimentation and analysis of results. This investigation was divided into three broad categories or phases. They included a pre-experiment phase, an experiment phase, and a post-experiment phase.

The first phase (pre-experiment) involved a thorough review of the literature to identify the relevant experimental techniques and current theories of motion sickness. It specifically included the techniques used to elicit a motion sickness response under controlled laboratory conditions. Also, this phase involved identification of the



physiological indicators that other investigators used to signal motion sickness onset and determine the reliability of those indicators. Finally, the literature review revealed the types of physiological monitoring sensors and data analysis techniques used previously. Most of that effort revolved around the expected capabilities of the equipment designed and built by two prior AFIT thesis teams (11; 12). The information gained from the literature review and careful study of the AFIT equipment allowed for completion of the final steps of the pre-experiment phase. Those final steps involved testing and calibration of equipment, development of experimental procedures and questionnaires, and solicitation of volunteers.

The second phase involved the actual experimentation. The experimental steps developed in phase one were applied to a sample population of informed and medically cleared human volunteers. Each subject in this group received a psychological profile questionnaire and a medical screening prior to participation in the experiment. The electronic transducers (physiological sensors) were attached to the subject, the subject's vestibular (equilibrium) senses were stressed, and the physiological data were collected on a Masscomp MC500 minicomputer and paper strip-chart recorders.

The final phase (post-experiment phase) consisted of data analysis, thesis write-up, and recommendations for further study.

## II. Motion Sickness

### Chapter Overview

The long recognized problem of motion sickness is historically outlined in the first part of this chapter. As evidence was slowly gathered, many old theories were disproven and new ones evolved. These current theories are briefly explained in the second part. This chapter goes on to describe the physiological indicators used to examine those theories and concludes by exposing the techniques employed to elicit the physiological responses.

### Historical Background

The history of motion sickness study is best approached in an era-type of framework, as done by Reason and Brand (46:1-27). They appropriately divided the time line into a pre-19th Century era, a 19th Century through World War II era, and followed with a description of the post-World War II era. With due respect to those authors, that format will be repeated here.

Pre-19th Century. This era has little to contribute to the study of motion sickness other than the illness has long been recognized as a motion disorder. As Reason and Brand point out, motion sickness probably was first experienced when man first used an artificial means of transportation (46:2). That was probably some type of ship or boat. Early Greek writings reference motion sickness. "In fact," Reason

and Brand state, "the term 'nausea' derives from the Greek word 'naus' meaning a ship" (46:2). Lacking a good scientific approach, or even an understanding of the physiological effects, early sufferers and observers contributed more myths and misconceptions than hard data. Their folklore remedies were often worse than the ailment.

19th Century through World War II. This era heralded in the enlightenment of scientific research. Although many folklore remedies and dubious cures remained, some inroads were made into actually understanding the physiology of the problem. Unfortunately a detailed knowledge of anatomic and physiologic functions was still some time off. The sixth sense of the vestibular system, meaning the equilibrium and motion sensing system, was not known or suspected until late in the century. Consequently, most 19th century researchers did not know where to place the locus of the motion disturbance. According to Reason and Brand, theories of the time generally implicated either the viscera (guts) or the circulatory system (blood). Hence, Reason and Brand coined these the "blood and guts" theories (46:5). Numerous proponents of one or the other or both camps theorized various etiological mechanisms for their pet theory. Schemes such as "cerebrial anemia" (due to blood pooling in the gut) and "abdominal vacuum" (due to descending guts and ascending diaphragm) were proposed (46:5). Most theories were based, at least in part, on some observation related to the illness.

Thus rapid movement of the eyes (nystagmus) was thought to somehow cause spasms of the cerebral capillaries resulting in vascular insufficiency of the brain and subsequent motion sickness symptoms (46:6). However, none of the early theories could account for the range of symptoms observed.

Finally, in the latter half of the nineteenth century, a number of physiological experiments pointed to the existence of a vestibular center. According to Reason and Brand, experiments by Menière (1861), Goltz (1870), and Breuer, Crum, Brown, and Mach (1873-74) identified the semicircular canals of the inner ear as the detectors of angular accelerations of the head (46:7). Later experiments by Breuer, Kreidel (1892), Wojatschek (1909), Abels (1926), and Sjöberg (1931) identified the otolith structures of the inner ear as detectors of linear accelerations. A landmark article by Irwin in Lancet (1881) named the semicircular canals as the "origins of equilibration" and implicated their role in "the true primary pathology of . . . seasickness" (46:8). But, as often happens with novel ideas, his assertions were mostly disregarded by his peers and the scientific publishers. Only after rigorous scientific research in the early 20th century and the necessity for answers in World War II did the vestibular theory gain widespread acceptance.

In the pre-war years the theory of sensory conflict began to emerge. Actually, Irwin had alluded to it in his 1881 paper when he stated that seasickness is promoted by

"dischord between the immediate or true visual impressions and a certain visual habit or visual sense of the fitness and order of things . . ." (46:16). What this means is that the eyes, the vestibular (inner ear), and body position senses send conflicting information to the brain thus promoting or exacerbating motion sickness. This hypothesis, and variations of it, forms the basis of current motion sickness theory and will be discussed in detail later.

The war years saw the greatest surge in motion sickness research. The reason for this is stated accurately by Reason and Brand:

The coming of the Second World War, and with it the need to transport very large numbers of unacclimatised troops by land, sea, and air, dramatically altered the status of motion sickness from being a banal and faintly ludicrous disorder to a problem of considerable military significance [46:17].

Both seasickness and airsickness were of major concern to the allies due to loss of efficiency, wash-out of aircrew members, and incapacitation of large numbers of shipborne troops. Consequently, extensive research was carried out in Britain, Canada, the United States, and Australia. Naturally the exigencies of the war demanded quick identification of highly susceptible individuals and/or fast, effective treatment for those already afflicted. Neither of these goals were effectively met. Little time was available for thoroughly researching the etiology of the illness, so most treatments treated the symptoms and not the causes. British researchers learned early on that trying to reduce individual

susceptibility could be done in some cases but it was much too time consuming and uncertain (46:18). They had somewhat better success with drug therapy but the side effects were often as bad or worse than the disease. These so-called remedies were issued to troops prior to the Normandy invasion, but one general said "that D-day had resulted in the greatest mass vomiting ever known in the history of mankind" (46:18). Despite the problems, drug therapy was seen as the easiest and most effective treatment.

Some wartime research, primarily Canadian and Australian, was aimed at understanding the basic etiology. A number of interesting findings resulted from this research. The Canadians found that the incidence of motion sickness is at its greatest in the 0.25 - 0.33 Hz motion frequency range (46:19). The implication of the vestibular system in motion sickness was further supported by the Australians when they found that small head motions greatly contributed to the onset of motion sickness (46:20). It is particularly noteworthy that one Australian, McIntyre, laid the groundwork for modern sensory conflict theory when he stated in 1941, "In most cases (motion sickness) is due primarily to disturbance of the sense of orientation in space, usually caused by an inflow of conflicting impulses from different receptors, in particular, the inner ear and the eye" (46:20). Reason and Brand write that McIntyre also reported the importance of visual cues and the proprioceptive (pressure

sensor) mediating effects of being in physical control of the vehicle (aircraft). These findings were supported and well-documented by later studies.

The wartime studies produced an abundance of data on motion sickness but relatively little in the way of unifying theories (46:20). Unfortunately, when the war ended, so did much of the interest in motion sickness research. It was not until the beginning of the spaceflight era that a real resurgence of interest occurred.

Post World War II. Due to the wartime research, the importance of the vestibular system in the etiology of motion sickness became quite clear. This meant that any new motion sickness theory would have to include the role of the vestibular system. But investigators in the post-war years tended to concentrate solely on the vestibular system, to the exclusion of the other contributing factors. Arguments then revolved around which vestibular component was primarily responsible - the semicircular canals or the otoliths (46:23). Evidence seemed to implicate the otoliths for the following reasons:

1. Angular motions of ships and airplanes were below the estimated levels for canal stimulation while linear motions were quite sufficient to stimulate the otoliths.
2. Nystagmus was not observed during seasickness and hence it was assumed that nystagmus could only be caused by canal stimulation.
3. Motion sickness could be caused by purely linear motion.

4. Symptoms could be alleviated by lying down or tilting the head back, indicating decreased otolith stimulation.

It was later found that these reasons were largely invalid, due to faulty assumptions and poor experimental methodology (46:24). At the time, though, this evidence led to the otolith overstimulation theory of motion sickness. This theory held that the otoliths were excessively stimulated in an unusual motion environment and led to the observed symptoms. However, this theory could not account for two critical pieces of evidence. The first is that motion sickness can be evoked in the absence of any motion at all. This is most commonly evidenced by motion sickness caused by a visual stimulus such as a motion picture of a roller coaster ride. The second fact is that the overstimulation theory does not account for the apparent adaptation which occurs during a prolonged exposure to abnormal motion. Thus, on an ocean voyage or in extended experiments the subject becomes acclimated to the unusual force environment and the motion sickness symptoms disappear. However, upon returning to the normal stationary environment, the symptoms reappear. Interestingly though, some symptoms that have a definite direction or sign associated with them (e.g. visual illusions) reappear with the opposite sign as originally perceived (15:354). This behavior cannot be explained by the vestibular overstimulation theory, but is accountable by a sensory conflict theory.



Because of the limitations of the otolith overstimulation theory, a more comprehensive sensory conflict theory was developed by researchers in the late 1950's and early 1960's. This was a more realistic approach since the human body does not rely on one isolated sense or organ to define the environment but uses instead the full repertoire of senses to get a composite view. Which sense, if any, contributes the most information will most likely be entirely a function of the stimulus and the physical circumstance of the individual. Thus in cinemagraphic induced motion sickness, the eyes are primarily involved, while in an enclosed centrifugal device, the vestibular organs are implicated. But in either case, all the senses are involved and some type of sensory conflict develops. Reason and Brand call this conflict "sensory rearrangement" and state that it is the first premise or condition for the sensory conflict theory (46:25).

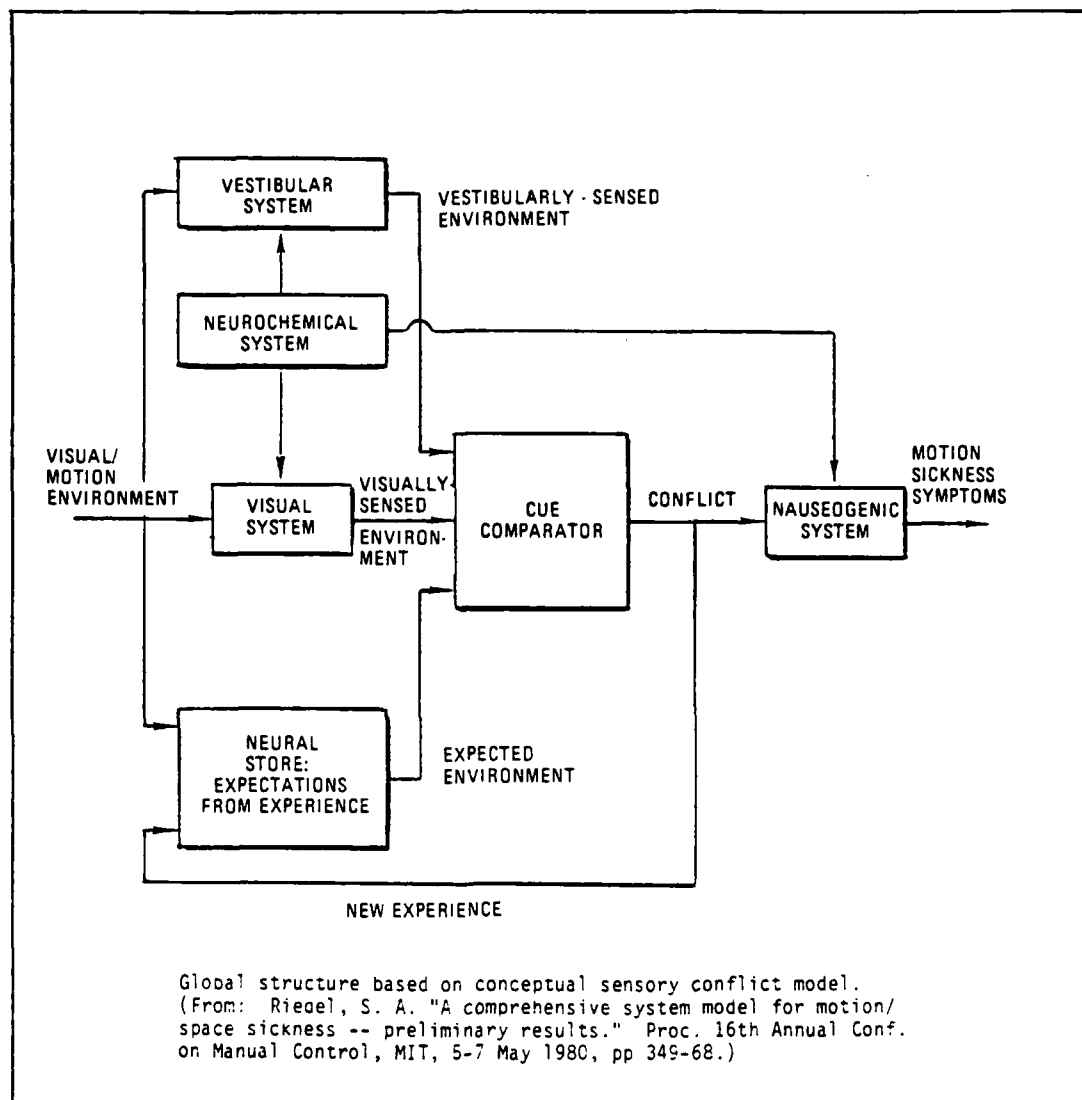
#### Current Theories

The sensory conflict theory is really the only one currently accepted as the most likely explanation for motion sickness. There may be different variations of the theory, but the basic premises are still the same. As stated in the previous section, the first premise for the sensory conflict theory is sensory rearrangement.

Sensory rearrangement is defined as the condition that

results from "motion information signalled by the vestibular receptors, the eyes, and the non-vestibular proprioceptors, [that] is at variance with the kinds of inputs that are expected on the basis of past experience" (46:25). Under "normal" movement conditions, i.e. usually upright walking, the vestibular apparatus, the eyes, and the proprioceptors (pressure sensors) send coordinated, appropriate information to the brain. The brain matches this information to that stored from previous similar motion environments and signals proper emotional and motor responses. When the information is not coordinated, inappropriate, or not in agreement with previous knowledge, the brain is confused and motion sickness results. This theory is shown diagrammatically in Figure 1.

Besides sensory rearrangement, Reason and Brand state another premise for the sensory conflict theory - "that irrespective of what other senses are party to these conflicts, the vestibular system must be implicated for motion sickness to occur" (46:26). Proof of this premise has been gained over many years of research and is summarized by Pitman and Yolton (45). They cite peripheral afferent nerve research in which investigators determined that visceral, visual, and extra-ocular eye muscle afferent nerves played some role, but were not crucial to motion sickness susceptibility (45:32,33). They then state "on the other hand, bilateral section of the vestibular nerve (CN



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Figure 1. Sensory Conflict Model

VIII) in animals seems to confer immunity to motion sickness" (45:32). Other experiments implicate structures in the central nervous system (CNS). Pitman and Yolton propose the following list as necessary neural elements in motion sickness (45:33):

1. Vestibular apparatus.
2. Vestibulocochlear nerve (VIII nerve).
3. Vestibular nuclei (VIII C.N. Nucleus).
4. Nodulus and uvula of the cerebellum.
5. Chemoceptive emetic trigger zone (C.C.T.Z.).
6. Vomiting center.
7. Efferent nerves involved in the emetic response.

These structures are shown diagrammatically in Figure 2 (46:250).

Obviously, the membranous labyrinth (vestibular apparatus) is a necessary component in motion sickness etiology. The vestibular system may be directly involved, as in provocative motion environments, such as shipboard, or may be indirectly involved, such as a visual stimulus. A visual stimulus will seek corroborative information from the inner ear and thus indirectly involve the labyrinth. This necessary involvement of the vestibular system has two important implications for the study of motion sickness. The first is that the organism must be responding to a changing environment. The vestibular system responds only to linear and angular accelerations, thus the motion



stimulus cannot consist solely of constant velocity components. The second implication is that there must be facultative linkages within the vestibular system, and between it and the remote senses (eyes and proprioceptors), as well as linkages with the brain. These linkages allow a stimulus in one part of the sensory system to crossflow to the other parts and evoke a motion sickness response. Reason and Brand identify this crossflow as one type of sensory rearrangement and term it "inter-modality conflict" (46:26). They also recognize a second type which they call "intra-modality" or "intra-labyrinthine conflict." This second type is a sensory conflict that occurs from disconjugate signals being sent from the semicircular canals and the otolith organs of the membranous labyrinth (Reason and Brand, pages 83-86, and Parker both give good descriptions of the vestibular system). Intra-labyrinthine conflict occurs in the weightless space environment where the brain receives appropriate motion information from the semicircular canals, but virtually no confirmatory data from the otoliths.

The two kinds of sensory rearrangement outlined above are further broken down into six specific types as shown in Table I. The "Visual-Inertial" category corresponds to the "inter-modality" type above, and the "canal-otolith" category corresponds to "intra-modality" conflict. The three types of conflict in Table I are explained as:

Type 1: when A and B simultaneously signal contradictory or uncorrelated information.

Type 2: when A signals in the absence of an expected B signal.

Type 3: when B signals in the absence of an expected A signal.

In all types however, the basic stimulus is a mismatch of current sensory information with the expected or stored sensory experience. Thus, as far as the brain is concerned, the new sensory information is in a new arrangement, or rearrangement. After a period of adaptation, the brain accepts the new arrangement and programs somatic responses accordingly. When the motion stimulus is removed, the brain is again faced with a sensory rearrangement and concomitant motion sickness. This was often observed following long sea voyages and was called "mal de débarquement." Kohl (28) hypothesizes that the location in the brain for comparing new sensory information with past experience is the limbic system. Because of the importance of this neural center, he prefers the term "neural mismatch" to sensory conflict in describing the etiology of motion sickness. Kohl describes the limbic system like a type of Grand Central station of the brain where "the significance of environmental stresses are translated into hormonal, adaptive, and autonomic responses" (28:465).

The importance of central processing of old and new information in the brain was demonstrated by Held and others as described by Lackner (29). A number of elegant

TABLE I

Some Everyday and Laboratory Examples of the Six Kinds of  
Sensory Rearrangement that can Provoke Motion Sickness

Type 1 (A and B)

Visual (A) - Inertial (B)

1. Watching waves over the side of a ship.
2. Looking out of the side or rear windows of a moving vehicle.
3. Making head movements while wearing some optical device that distorts vision.

Canal (A) - Otolith (B)

1. Head movements made about some axis other than that of bodily rotation - cross-coupled angular accelerations.
2. Low frequency oscillations: between 0.1 and 0.3 Hz.

Type 2 (A not B)

Visual (A) - Inertial (B)

1. "Cinerama Sickness."
2. Operating a fixed-base vehicle simulator with a moving visual display - "simulator sickness."
3. "Haunted-Swing" type of fairground device.

Canal (A) - Otolith (B)

1. Weightless flight - "space sickness."
2. Calorific stimulation of the outer ear.
3. Positional alcoholic nystagmus associated with alcohol and heavy water.

Type 3 (B not A)

Visual (A) - Inertial (B)

1. Reading a map in a moving vehicle.
2. Riding in a vehicle without external visual reference.
3. Being swung in an enclosed cabin.

Canal (A) - Otolith (B)

1. Rotation about an Earth-horizontal axis.
2. Any rotation about an off-vertical axis.
3. Counter-rotation.

(Adapted from 46:106)



experiments showed that effective sensory-motor coordination depended on constant feedback and sensory comparison in the brain. According to Lackner (29:149), Held developed concepts of "correlation storage" and a "comparator" to account for learned patterns of movement and comparison feedback with new motions. Later studies by Lackner and others indicated that adaptation to a new sensory environment depended on a spatial or sensory discordance (29:153). Thus not only does sensory rearrangement lead to adaptation, but sensory-motor adaptation depends on that rearrangement. One caution seems in order here. Held's "correlation storage" and similar concepts propounded by other researchers may not be feasible in the form they were envisioned. They were proposed in terms of stored patterns of neural efferent commands. Supposedly, an organism then compares the efferent and reafferent neural signals to stored patterns of these signals in the brain or what Held calls the "exposure-history" (29:153; 46:105). The term "efferent" here refers to neuromotor signals from the brain to the muscles, and "reafferent" means neural feedback from the proprioceptors, eyes, and inner ear to the brain indicating body position and movement. Lackner contends that this concept of stored efferent "memory traces" is absurd because of the infinite number of possible combinations of neural signals (29:154). He proposes instead that "adaptation to sensory rearrangement often

takes the form of 'postural remappings' (i.e., changes in the apparent position of parts of the body in relation to one another) rather than motor remappings" (29:155). Postural remapping would be a simpler process for the brain to manage since it would involve only a single transformation as opposed to the numerous motor efferent responses.

Whatever the actual form the "exposure history" takes, the result is still the same. Sensory rearrangement or neural mismatch occurs and the body responds with symptoms of motion sickness. Symptoms may vary widely in intensity from one individual to the next but the pattern of symptoms is fairly constant, as will be seen in the next section.

#### Physiological Indicators

A basic concept in physiology is that of homeostasis. This term is used by physiologists to mean maintenance of stable, or constant, conditions in the internal body environment (23:3). Whenever the environment is disturbed, the body takes active steps to return to its homeostatic condition. Thus when an individual does strenuous physical work and raises the body's temperature, the body responds by activating thermoregulatory systems to bring the temperature back within tolerance. However, some homeostatic mechanisms are counter-productive because the responses may no longer be appropriate to the stimulus, secondary responses occur

that do not serve the homeostatic purpose, or the mechanism is understood incompletely. In the case of motion sickness, all three reasons may apply.

In its undisturbed functioning state, the vestibular system serves an important homeostatic need. It works in concert with the visual and proprioceptive systems to provide information on where the body and its associated parts are and how they are moving. This constant feedback to the CNS allows coordinated, appropriate movement to occur. It will also allow rapid response to a threat for survival of the organism. The entire system, though, depends on fine integration of sensory input with motor output. Graybiel hypothesizes that this integration has evolved through natural selection and is so deeply rooted that it is transparent to the organism (15:351-367). He cites the lack of vestibular disturbance under natural conditions as evidence of this complex integration and uses the term "silent elegance" to describe its effectuation in the organism (15:351). But although it works very well in its silent natural role, the vestibular system does not work so well, and certainly not silently under unnatural conditions. We might say that the vestibular system is finely tuned to the natural bipedal locomotion of man and is easily disturbed by any type of artificial or unnatural locomotion. When the vestibular system is disturbed, it elicits the motion sickness symptoms. These symptoms

generally fall into two main categories which Graybiel has termed V-I and V-II (15:352).

Vestibular Disturbances and Immediate Effects.

Graybiel's V-I category includes disturbances to the vestibular system itself and collateral systems that normally receive vestibular activity. These disturbances cause reflex reactions that often include the following:

1. A "rotation" or "tumbling" sensation.
2. A visual illusion of motion called Coriolis oculogyral illusion.
3. Coriolis-induced nystagmus (rapid eye motion).
4. Dizziness.
5. Motor incoordination (ataxia) (15:354).

Because these are reflex responses to vestibular stimulation, they are not formally considered part of the motion sickness syndrome. They may be evoked by other means (e.g., caloric stimulation), which may or may not lead to motion sickness. The fact that the preceding disturbances are reflex reactions is supported by the following common characteristics:

1. Short latencies.
2. Maximal response to the initial stimulus.
3. Modulation by secondary influences.
4. No apparent temporal preservation after stimulus cessation.
5. Variable time course of adaptation.
6. Need for readjustment on return to the stationary environment (15:355).

Without accurate physiological monitoring equipment, or detailed qualitative comments from the subject, these initial reflex reactions might be missed by the experimenter. However, the second category of symptoms is easily observable and represents the "typical" symptomatology of motion sickness.

Secondary Effects, Signs, and Symptoms. The second category of symptoms (Graybiel's V-II category) is an indirect result of the sensory conflict, usually arising from vestibular disturbance. Graybiel terms this secondary influence an example of "system crossover manifestations" (15:355). By this he means that the symptoms originate from two normally independent systems but appear to be the manifestation of one. For this to occur, a crossover must occur via some facultative linkage. As stated earlier, evidence seems to implicate the limbic system of the brain as a likely crossover point with the emetic center and chemoceptive trigger zone (CTZ) as initial effector sites. Graybiel argues that the "once-removed" origin of the secondary symptoms ensures that they make no physiological sense in terms of response to the initial stimulus or in restoring homeostasis. Since these symptoms are superimposed on those in the V-I category, the investigator faces a bewildering array of signs and symptoms. Furthermore, secondary symptoms may lead to third order complications, i.e., vomiting leading to electrolyte

imbalance. However, some combination of the signs and symptoms presented in Table II is generally accepted as indicative of motion sickness.

The "Big Four" Symptoms. The most commonly reported symptoms are pallor, nausea, vomiting, and cold sweating, with nausea the most frequent complaint (40:3; 46:39). Some investigators claim that pallor always precedes nausea and thus may be the most accurate predictor of motion sickness (7:507). However, pallor is usually subjectively assessed and may vary widely from subject to subject and one experimental run to the next. Nausea, or its milder form "stomach awareness," is somewhat more accurate, and if reported by a non-coached or naive subject is quite reliable. Almost any motion stimulus if severe enough or continued long enough will result in nausea and eventually vomiting.

From an experimental point of view, vomiting is usually taken as the end point for eliciting a motion sickness response (15:365). Although most sufferers report symptomatic relief after vomiting, it is still not a

TABLE II  
Motion Sickness Manifestations

Cardiovascular

Changes in pulse rate and/or blood pressure.  
Increase in tone of arterial portion of capillaries in  
fingernail bed.  
Decrease in diameter of retinal vessels.  
Decrease in peripheral circulation (especially head pallor).  
Increase in muscle blood flow.

Respiratory

Alterations in respiration rate and type.  
Sighing or yawning.

Gastrointestinal

Inhibition of gastric intestinal tone and secretions.  
Salivation.  
Gas or belching.  
Epigastric discomfort or awareness.  
Sudden relief of symptoms after vomiting.

Temperature

Decrease in body temperature; coldness of extremities.

Visual System

Nystagmus.  
Ocular imbalance.  
Dilated pupils during emesis, small pupils at other times.

Behavioral

Apathy, lethargy, sleepiness, fatigue, weakness, malaise.  
Depression and/or anxiety.  
Mental confusion, spatial disorientation, dizziness,  
giddiness.  
Anorexia, unusual sensitivity to repulsive sights or odors,  
or excessive discomfort from previously tolerable stimuli  
such as heat, cold, or tightness of clothing.  
Headache, especially frontal headache.  
Decrease in muscular coordination and psychomotor  
performance.  
Decrease in time estimation.  
Decrease in motivation.  
Changes in muscle tension.

(Adapted from 41:143)

pleasant experience. Experimentally, it is often better to use nausea as the end point and control the nauseogenic stimulus to prevent symptom progression to the vomiting level. Reason and Brand tried to answer the question of defining an experimental end point and listed two approaches. The first approach was that described above: use nausea as an end point since vomiting is undesirable. The second approach uses a numerical index or ordinal scale of motion sickness intensity as an end point. Some early investigators used a "sickness index" based on subjective or objective inputs, including sweating, nausea, and vomiting, while later workers defined a motion sickness severity scale to judge levels of illness below vomiting (16:453; 39:7; 46:80). A third technique employs a subjective magnitude estimation of the level of motion sickness discomfort (2:773). The rating scheme most commonly in use now is that developed by Graybiel and his associates (16). However, even that well-defined approach depends heavily upon subjective input. A more effective technique is to use an objective, quantitative measurement. Graybiel recognized the need for objective, quantitative data when he stated:

It is unfortunate that so little attention has been given to the earliest appearance and disappearance of V-II symptoms along a time axis. Only in this way will we gain some notion regarding latency and whether we are dealing with first-, second-, or even third-order symptoms or their complications [15:358].

Graybiel went on to describe one set of studies which did look at a time course progression of symptoms and noted



that the first recorded response was cold sweating, followed shortly by stomach awareness and nausea (15:358). He explained the short latency (3-4 seconds) was due to neural crossflow from the vestibular system to the origin of the autonomic response (sweating) by some facultative linkage. Also, an observed preservation of the effect was probably due to release of a chemical factor or prolonged reverberating neural activity. Both the short latency effect and extended response of cold sweating were also noted by Reason and Brand when they cited McClure (46:42). In that study, two distinct sweat responses were observed, "that from the arousal sweat area on the palm, and that from the thermal sweat area on the dorsal hand and forearm" (46:42). The first was associated with a short latency "orientation reaction" to any novel or unusual stimulus while the second was a slower evolving response characteristic of motion sickness symptoms. They caution investigators to be aware of this difference and treat the first response suspiciously. Work by Parker (1971) confirmed the use of the forearm as an apparently reliable indicator of motion sickness response. This evidence suggests that further time course studies should be done with these and other physiological indicators. Such was the intent with the current investigation.

Other physiological indicators besides the "big four" of pallor, cold sweating, nausea, and vomiting are less

consistent and reliable but do frequently occur (46:45). These other symptoms include the remaining items in Table II. A thorough review of these symptoms is given in Money (40).

Cardiovascular Symptoms. Cardiovascular Symptoms, including pulse rate and blood pressure, have been observed often in motion sickness subjects but they have been very variable and unreliable (46:54). Crampton (7) noted certain trends among several variables, but concluded that the only reliable indicator seemed to be pallor. Among the sick subjects, systolic and diastolic pressures fell, while pulse rate and digital pulse amplitudes (indicating vasoconstriction) increased (7:505). These symptoms may be useful to observe for additional data, but by themselves are not conclusive enough to predict motion sickness. Graybiel and Lackner reached the same conclusion with blood pressure, heart rate, and temperature (20:211). Two problems are immediately evident, however, when comparing these studies. The first is that if vomiting is used as the end point of the experiment, the act of vomiting causes cardiovascular changes (46:57). The second problem is that many different techniques were used to elicit motion sickness responses and the types of equipment and methods of measurement varied widely. Generalizations are therefore very suspect and difficult, if not impossible, to prove.

Respiratory Symptoms. Respiratory changes, as

shown in Table II, often accompany motion sickness but the direction and type of change is again very variable. Crampton and others noted a general increase in respiration but this was at variance with a number of other researchers (7:507; 40:6; 46:57). In some cases the respirations were slow and shallow as opposed to fast and deep (40:6). Additional signs may include sighing or yawning, a change in the regularity of respirations, and possibly a shift from diaphragmatic to thoracic breathing (9:14). As with the cardiovascular symptoms, the respiratory changes are not consistent between individuals or for the same individuals at different times. But these symptoms need to be measured in a comprehensive time-line study to examine possible interrelationships among all the variables.

Gastrointestinal Changes. Since nausea and vomiting are two of the cardinal symptoms of motion sickness, a lot of emphasis has been placed on studying gastrointestinal changes. This area shows a surprising consistency in reported symptoms. Most researchers have reported that gastric tone and motility decrease with the onset of motion sickness (9:2; 40:6; 46:58). This change is often accompanied by duodenal spasm, decreased intestinal tone, increased or decreased gastric secretions, salivation, swallowing, diarrhea, and flatus or belching (40:6). Although Crampton noted a more abrupt decrease in gastric tone, and some brief changes in tone level among his sick

subjects, he could not clearly correlate these changes to the reports of nausea or vomiting (7:504). However, Reason and Brand point out that Crampton used an intragastric recording device (stomach balloon) which, by its presence, could have interfered with the recordings (46:58). Most recent studies use external electrical transducers to avoid that problem.

Gastric tone has very recently become a significant concern in space motion sickness. Dr. William Thornton, a NASA astronaut on Spacelab 2 made the important observation that gastric hypomotility was evident in space-sick astronauts (42:35-18). He felt that this loss of gastric tone might be an important indicator or perhaps contributor to the space sickness syndrome. Soviet researchers have also noted loss of gastric tone among cosmonauts and think that this may contribute to other gastrointestinal problems (41:201).

Miscellaneous Signs. Other signs of motion sickness often reported in the literature include: body fluid biochemical changes, body temperature rise or fall, visual abnormalities, muscular hypertension, and behavioral effects. Some researchers have also noted changes in electroencephalogram (brain wave) patterns (46:63).

Changes in biochemistry have been studied extensively, particularly in recent years in relation to drug studies (4; 14; 17; 18; 19; 36). Since the present work did not attempt

to investigate biochemical changes of motion sickness, they will not be reviewed here.

Temperature changes have been frequently reported and include basal body temperature, skin and mouth temperature, and the extremities (40:7). Crampton observed a body temperature decrease in his subjects even without movement-induced surface cooling (7:506). However, he attributed the temperature drop to the effects of sweating and increased respiratory cooling.

Money (40) listed the following visual changes: ocular imbalance, no ocular imbalance, constricted pupils, dilated pupils (particularly during emesis), and the reflexive nystagmic response. Besides nystagmus, these signs are very unreliable as motion sickness indicators. As noted earlier, nystagmus is not normally considered a motion sickness symptom since it is a reflex response that can be elicited by other means. However, since it is so often observed in experimental studies, it must be included as a possible sign of motion sickness (34:469).

Skeletal muscle tension has been reported as a symptom of motion sickness. Whether the tension is due to the sensory conflict or to overall stress resulting from the illness has not been determined. As an indicator of overall stress, muscle tension measurement may still be valid since it indicates the underlying psychological and physiological state of the subject.

A more definitive indicator of the psychological state of a motion sick individual may be the electroencephalogram (EEG). The EEG can be analyzed to measure the electrical activity of the brain in discrete frequency bands. Although the brain waves of a normal human are usually irregular and show no apparent pattern, they frequently can be considered to lie in discrete patterns (23:675). As explained in the next chapter, the brain wave patterns of interest in the current study are the alpha, beta, and theta waves. At least two possibilities might be observed in this regard. The first is that beta II (high frequency beta) or possibly theta waves might occur due to increased levels of tension or stress. The second possibility is the possible appearance of alpha waves due to a quieting of mental activity. Of course, the third possibility of no change or no discernible pattern is also present. Some previous investigations have failed to find any correlation between brain wave activity and motion sickness, while others have noted the appearance of alpha waves indicating the apparent depression of mental activity (46:63). The latter finding seems in agreement with some clinical observations of drowsiness and lethargy in victims. Once again, although EEG patterns may not be independently conclusive, they may add to the overall pattern and indicate underlying physiological and behavioral changes.

Behavioral Changes. Numerous behavioral changes

have been associated with motion sickness, the most common one probably being malaise, meaning a general feeling of ill boding or depression. Most of the humorous (except for the victim) anecdotal accounts of motion sickness relate to behavioral responses. Feelings of abject misery often result in what Money (40:7) cites as "physical and moral prostration."

Many attempts have been made to classify motion sickness victims into certain behavioral or physiological types. A study by Collins and Lentz, using primarily a battery of written tests, found that motion sickness susceptible individuals showed high levels of anxiety and had indications of neuropsychiatric and psychosomatic problem tendencies (4:587). These authors also found that susceptible individuals showed a correlation with introversion and neuroticism scales. The personality traits, as determined by Collins and Lentz, are summarized by Connors et al. (5):

Nonsusceptibles can be characterized as emotionally stable, venturesome, self-assured, relaxed, adjusted, thinking-oriented, not neurotically disposed, and good leaders. Susceptibles are defined as emotionally oriented tender-minded, and subjective, and as possessing traits generally the opposite of those defining non-susceptibles [5:44].

Other work described by Connors and her co-authors confirmed the anxiety tendency of susceptibles and went on to classify individuals according to "autonomic-functioning profiles" (5:44). This classification scheme, developed by

Cowings and her associates at NASA's Ames Research Center, separates subjects into "sympathetic dominant" and "parasympathetic dominant" groups (5:45). According Connors:

Individuals with sympathetic-dominant autonomic profiles showed less anxiety, were less able to perceive their own autonomic functioning, and, under conditions of unusual vestibular functioning, showed fewer symptoms of motion sickness than did parasympathetic-dominant individuals [5:45].

Although these personality traits for susceptible subjects agreed somewhat with those described by Collins and Lentz, the connection between autonomic dominance and motion sickness susceptibility was not clear. Non-susceptible subjects in the study by Collins and Lentz showed traits normally associated with parasympathetic dominance (emotional stability, well-adjusted, extroverted, etc.). But according to Cowings and her co-workers, these same individuals would be classified as sympathetic-dominant (5:45). Apparently, motion sickness cannot be clearly predicted on the basis of behavioral-type, at least using current methods.

The susceptibility groupings used by Cowings and her associates are really the resurrection of a popular classification scheme in the early part of the the twentieth century. According to Reason and Brand, a scheme proposed by Eppinger and Hess in 1917 divided susceptible individuals into "vagotonics" or "sympatheticotonics" based on pulse rate and blood pressure (46:50). The theory was that "vagotonics" experienced symptoms manifesting excessive



activity of the parasympathetic nervous system, while "sympatheticotonics" had heightened activity of the sympathetic nerves. The symptoms associated with these types were headache and malaise with no vomiting for the first type, and frequent vomiting with rare headaches for the latter type (46:50). This "head-type" verses "stomach-type" of classification was debated and, as the "blood and guts" theories that preceded it, eventually succumbed to lack of evidence. It did, however, emphasize the importance of time-line studies of interrelated symptomatology and may still have relevance to temporal progression of motion sickness. Reason and Brand suggest that relatively susceptible individuals, when subjected to a mild stimulus of long duration may first feel "head" symptoms followed later by "gastric" symptoms (46:52). Nonsusceptible or resistant subjects may feel only mild "head" symptoms or none at all under the same conditions. When the stimulus is severe and sudden, the susceptibles may feel "gastric" symptoms immediately while the resistant individuals may have a "head" symptom period which may or may not be followed by "gastric" problems. Thus the "vagotonic" versus "sympatheticotonic" distinction might be related more to a temporal effect and inherent susceptibility rather than nervous system response. The same conclusion was reached by Reason and Brand: "We can suggest, therefore, that the particular reactions observed depend upon the complex

interaction of three factors: the severity of the provocative stimulus, the basic susceptibility of the individual and the length of time for which he is exposed" (46:52).

#### Techniques for Eliciting a Motion Sickness Response

This section briefly describe the methods used in a laboratory to provoke a motion sickness response for experimental purposes. It specifically does not cover the types of motion known to cause motion sickness under non-experimental or "natural" conditions. As pointed out earlier in this chapter virtually any type of motion, besides the evolutionarily natural bipedal upright locomotion, can cause motion sickness. The intent here is to outline specific techniques useful for evoking and studying motion sickness under controlled under controlled laboratory.

Even with the above limitation, the number of provocative stimuli is very large. The stimuli can be broken into two basic groups: those that involve movement of the subject, and those that do not. The former category includes various types of angular motion, linear motions, swing motion (pendulum), normal body motion with altered visual input, and combinations of the above. The non-motion category of stimuli includes visual illusions of motion (cinemagraphic sickness), caloric stimulation of the

vestibular apparatus, and the special case of free-fall (microgravity) where the subject is not usually considered to be in motion, but from an inertial reference frame point of view actually is moving. Because of its more limited applications, the latter category will be considered first.

Non-motion Stimuli. Visual illusion of motion is a non-motion stimulus that creates a sensory conflict in the brain by eliciting conflicting responses from the eyes and position senses. The stimulus is usually some type of motion picture displayed on a wrap-around screen so the eyes misinterpret the information (44). The eyes mistakenly signal the brain that according to the visual scene, the body is in motion. Theoretically when the vestibular system and proprioceptors signal that the body is at rest, sensory conflict and motion sickness results.

Caloric stimulation of the inner ears is essentially the reverse process of that described above. When one external ear canal is irrigated with a relatively warm fluid (e.g., water at 44 degrees Centigrade) while the other canal is irrigated with relatively cool fluid (30 degrees Centigrade), reflex nystagmus occurs (47:218). If continued long enough this canal stimulation may signal a tumbling sensation to the brain which is contra-indicated by the eyes. Again this sensory conflict may lead to motion sickness (41:142). Caloric stimulation of the semicircular canals is used most often as a test for normal vestibular

function by measuring the rate of decay of the nystagmus (3:124).

Free-fall is a special case of non-motion induced motion sickness. It is special because it involves a completely new stimulus compared to anything the individual might have experienced before. Although perhaps motionless in the relative reference frame, the subject is actually moving quite rapidly (falling) in the inertial reference frame. This, in effect, produces a zero-gravity (or actually a microgravity) condition. The effect on the organism is profound (41:127). The otoliths in the utricles and saccules of the vestibular apparatus depend on gravity to continuously send body position information to the brain. In the absence of gravity, the neural information is either missing or meaningless. However, the semicircular canals respond to angular accelerations and function in the presence or absence of gravity. Under normal conditions, the brain relies on coordinated and confirmatory data from all parts of the vestibular system. Since this is not possible in free-fall, once again sensory conflict occurs. Although this is not a typical laboratory technique, free-fall has been used by a number of investigators to study the particular form of motion sickness it elicits (27; 30; 32; 33; 38; 42). The study of free-fall induced motion sickness is a very large subset of motion sickness studies in general and beyond the scope of the present effort.

Motion Stimuli. The category of stimuli that involves movement of the subject is very large. Almost any type of motion that results in rapidly changing force vectors and/or causes sensory conflict, can cause motion sickness.

Linear motion, especially vertical oscillation, and two-pole and four-pole swings have been used to elicit motion sickness (7:501; 22:555; 40:10). Vertical oscillation at frequencies of 15 to 22 cycles per minute (0.25 to 0.37 Hz.) and acceleration levels of 0.2 to 0.4 G have been particularly effective (9:4). Money (40) noted that "using a vertically oscillating cab, it has been shown that the incidence of motion sickness varies with wave duration (period), acceleration level, energy per wave, and rate of doing work in oscillating the cab" (40:10). He also observed that no single characteristic had more effect than any other, although when the frequency was greater than 32 cycles per minute (0.53 Hz.), motion sickness was not elicited. This agreed with findings using swings, "a radius of close to 15 feet and a frequency of 15 cycles per minute are most effective . . . lower radii (with lower frequency of swinging) or smaller radii (with higher frequency of swinging) result in a lower incidence of sickness" (40:11).

Normal walking can also cause motion sickness when the visual system has been altered. This is often done by allowing the subject to wear special glasses or goggles. One type of goggles reverses the visual scene while another

type inverts it. Both types produce motion sickness by sending visual signals to the brain that do not agree with vestibular and proprioceptive senses (40:16). It is interesting to note, however, that according to a recent Public Broadcasting Station television presentation entitled "The Brain," an individual made ill by the above method will quickly adapt to the new visual scene. The motion sickness symptoms will subside and remain in submission as long as the goggles are worn. However, when the goggles are removed, the motion sickness will return until a new adaptation period has elapsed.

Another visually-induced motion sickness technique is the use of a rotating or counter-rotating dome, drum, or wall. This method has the subject slowly rotating on a platform or chair while the visual field rotates in the same direction at a slower speed, or in the opposite direction. Since the motion the subject actually experiences is different from the apparent motion in the visual field, sensory conflict results.

Angular rotation about an earth-horizontal axis produces motion sickness in an unusual way since angular acceleration is not a primary component. In this case, the constant velocity rotation does not stimulate the semicircular canals but the constantly changing gravitational vector (linear component) strongly stimulates the otoliths (40:11). This method produces

intralabyrinthine conflict and concomitant motion sickness.

Perhaps the most common method for eliciting motion sickness in the laboratory is cross-coupled angular acceleration. The subject is spun or rotated about a vertical axis and allowed or directed to make head motions out of the rotational plane. These motions are frequently complex since they involve linear and angular components, simultaneous linear or angular accelerations in several planes, or combinations of the above (51). In both human and animal experiments, it has been shown that complex motions are much more nauseogenic than single component motion (9:4; 40:11). By carefully controlling the exposure of a test subject to these complex motions, the intensity and rate of onset of motion sickness symptoms can be controlled. Graybiel and Wood (1969) showed in studies using a slow rotation room that if the rate of rotation and frequency of head motions were increased the severity and rate of onset of symptoms were greater. Thus the researcher can control the nauseogenic stimulus. In the present study, a cross-coupled angular acceleration stimulus was administered by means of a rotating chair. This chair and its associated equipment will be described in the next chapter.

### III. Computerized Biophysical Data Acquisition System

#### Chapter Overview

This section describes the overall system elements used to accomplish this study. Each monitoring device is detailed, along with a brief description of the physiological function studied. The basic capabilities of the data collection devices are covered at the end of this section.

#### System Overview

The system essentially consisted of the rotating chair and related controls, a human volunteer test subject, physiological monitoring devices, and instruments to record the test subject's reactions to adverse motion stimuli. The overall system concept has been previously discussed in thesis efforts by Capts Earl and Peterson (11) and Capts Fitzpatrick, Rogers, and Williams (12). Note, however, that major modifications were made to both equipment and software to tailor the data collection to the requirements of this project, so numerous specific details have changed since the previous efforts were finished.

A block diagram of the system is shown in Figure 3.

#### Rotating Chair

The multiaxis motion simulator assembled by Earl and Peterson was used to elicit motion sickness responses (11).



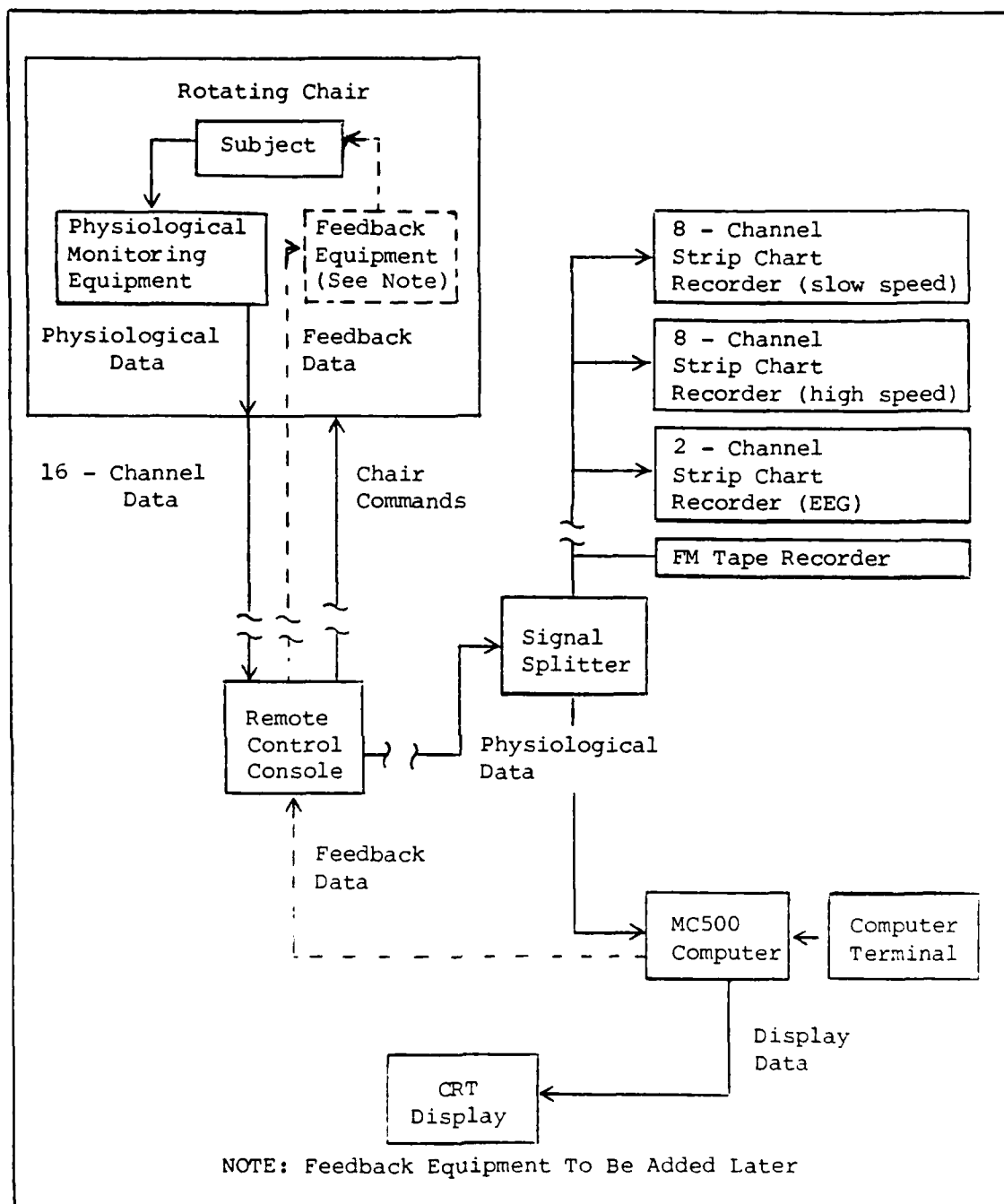


Figure 3. System Configuration

In this study, subjects were rotated about the vertical axis only. A hood to cover the passenger compartment and filter out unwanted visual stimuli was available for use and was actually tested on one subject. However, hood use was discontinued because unwanted visual stimuli still entered through various openings and ventilation was poor.

The chair's rate and direction of rotation was controlled by a separate control console. In Figure 4, a picture of the console is shown. The fast control settings were used to attain a 25 rpm rate when required by the protocol. The maximum rotation rate for the slow control settings is 14 rpm. See Chapter IV for the operational procedure used in data collection. In an emergency, the subject could stop the rotation by pushing an "emergency stop" button on the chair's control console. Due to possible undesirable after effects of a sudden stop on the vestibular system, subjects were asked not to use the button unless absolutely necessary.

A photograph of the chair is shown in Figure 5.

#### Human Test Subjects

Test subjects were Air Force-member, male volunteers from the Air Force Institute of Technology. Solicitation was by personal contact and publicity. No attempt was made to select subjects to fit certain background requirements; availability and willingness were the main selection

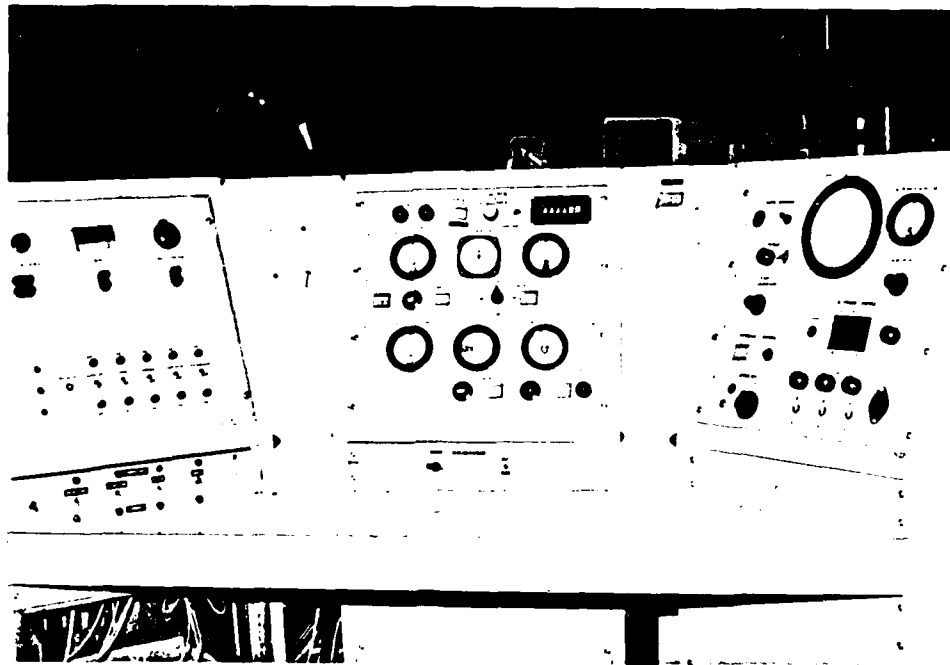


Figure 4. MATS Chair Control Console



Figure 5. MATS Chair

criteria. Both rated and non-rated subjects were used. Females were not solicited because of the location of certain physiological monitoring devices.

#### Physiological Monitoring Equipment

Each test subject was outfitted with a number of electrodes, strain gauges, and other apparatus to measure physiological responses to adverse motion stimuli. Special acknowledgement is given to Dr. William Czelen, M.D., who designed and constructed the devices described on the following pages. For a diagram showing the placement of each device, see Figure 6.

Electrodes. The electrodes used were of the silver/silver chloride type because of stable half-cell potentials and low noise characteristics (9:13). Two commercially available disposable electrodes were used. Andover Medical "Huggables" Infant Monitoring Electrodes were placed on all head locations. At other locations (besides the EMG location), NDM Corporation Silvon Stress Test ECG electrodes were used. For the EMG, three reusable, silver/silver chloride electrodes with electrolyte gel were placed over the muscle mass of interest.

Electrocardiogram (EKG). The purpose of the EKG is to measure the electrical potentials generated by the active heart. Electrodes placed on opposite sides of the heart detect the changes and allow recordings of the electrical

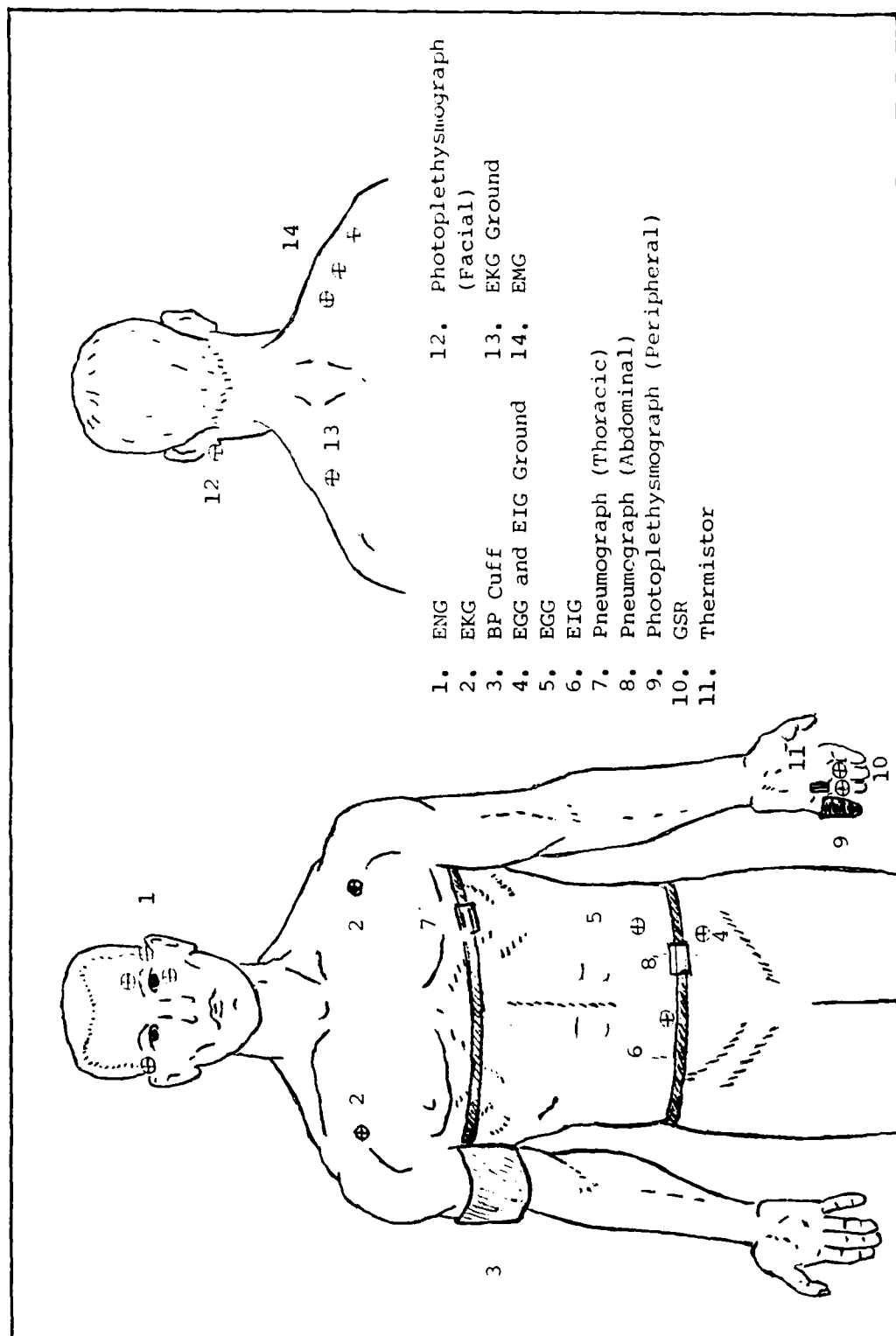


Figure 6. Electrode Placement Locations

current differences (23:176). For this study, the EKG was used to record variances in heart rate and any possible changes in heart rhythm. The frequency response of the transducers was 0.05 Hz to 30 Hz with an amplitude in the range of a few millivolts (9:13).

Sphygmomanometer. The purpose of a sphygmomanometer is to record arterial blood pressure. Blood pressure varies with the heart's rhythm, reaching a maximum (systolic) pressure with each ventricular contraction of the heart and reaching a minimum (diastolic) pressure with each ventricular relaxation (21:180). Blood pressure is normally measured in units of millimeters of mercury (mm. Hg), with typical values for a normal young adult being 120 mm. Hg systolic and 80 mm. Hg diastolic (23:246). The sphygmomanometer in this study was an Astropulse 90, an automatic, digital device manufactured by Marshall Electronics, Inc. of Skokie, Illinois. The Astropulse 90 included a built-in printer. Outputs were obtained via remote control at the onset time of critical symptoms. Each output included a time of recording, systolic and diastolic blood pressure, and heart rate. See Figure 7 for a sample output.

Ballistocardiogram. The ballistocardiogram is used to measure the force of rebound of the chest from cardiac impact.

Electroencephalogram (EEG). The EEG is used to record

```

6-18  3:27 PM
SYS  DIA  PULSE
104  86   75
mmHg mmHg /min

6-18  3:45 PM
SYS  DIA  PULSE
214  168  62
mmHg mmHg /min

6-18  4:00 PM
SYS  DIA  PULSE
197  115  77
mmHg mmHg /min

6-18  4:07 PM
SYS  DIA  PULSE
179  91   68
mmHg mmHg /min

```

Figure 7. Sphygmomanometer Sample Printout

changes in the brain's electrical activity. The intensity and pattern of this electrical activity are highly dependent on the brain's level of excitement (23:675). These undulations in the recorded electrical potentials are called brain waves.

Brain waves recorded at the surface of the scalp vary in intensity from 0 to 300 microvolts, and vary in frequency from one cycle every few seconds to 50 or more cycles per second (23:675). Although much of the time these brain waves are irregular and no general pattern is discerned, distinct patterns may appear (23:675). The patterns of interest to this study are the alpha, beta, and theta waves (9:17).

Alpha waves occur at an intensity of about 50 microvolts, a frequency of 8 to 13 Hz., and are found in almost all normal adults in a quiet, resting state while awake (23:675). These waves disappear when attention is directed to some conscious mental activity (9:17). Beta waves occur at a frequency of 14 to 50 Hz, and are most frequently recorded from the parietal and frontal regions of the scalp (23:676). At the higher end of their frequency range, these waves are associated with intense central nervous system activation or with tension (9:17). Finally, theta waves have frequencies of 4 to 7 Hz. Theta waves are associated with emotional stress in adults, particularly during disappointment and frustration (23:676).

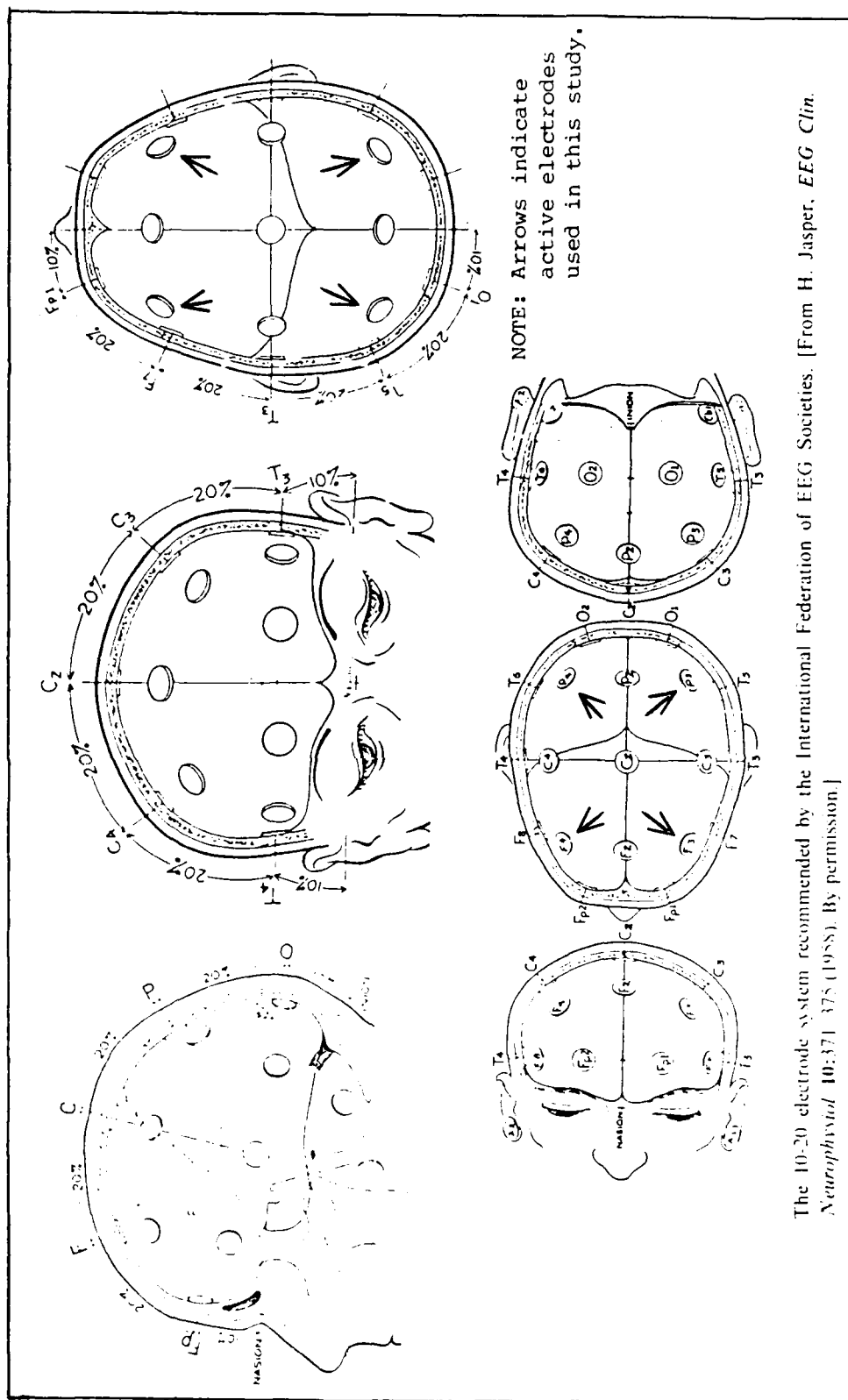


See Figure 8 for placement of EEG electrodes.

Photo-plethysmographs. The function of a photo-plethysmograph is to optically measure blood flow volume (skin pallor) changes at desired locations in the body. A change in skin pallor is a well-established indicator of motion sickness (46:41-45). As blood flow increases, the plethysmograph detects the corresponding increase in the area's opacity to light. The frequency response of the system is 0 to 5 Hz. with a fundamental of 1.3 Hz. (9:13). This study measured pallor at two locations: the face and the little finger.

The facial photo-plethysmograph consisted of a clip-on device attached to the right earlobe of the test subject. A light was located on one prong of the clip, with a sensor located on the other prong. The sensor detected changes in the light transmitted by the light which indicated varying blood flow volume. The ear was covered by an ear hood to prevent extraneous light rays from affecting readings.

The peripheral (finger) plethysmograph consisted of a hardened plastic tubular apparatus, totally enclosed at one end, that was fastened snugly with a strip of velcro. Within the enclosed end is a light located above the fingertip. A sensor was located on the volar surface of the distal phalanx to detect changes in the amount of light transmission. Operation was similar to that described for



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Figure 8. EEG Electrode Placement

the facial plethysmograph device.

Thermistor. The thermistor is used to measure peripheral skin temperature.

Placed directly onto the skin of one finger, the thermistor was held in place by a Galvanic Skin Response Sensor.

Galvanic Skin Response (GSR) Sensor. GSR has been studied extensively and has been used in previous attempts at biofeedback control of physiological parameters (9:14). The GSR is a change in the electrical conductivity of the skin often associated with tension or anxiety (11:II-10). Also known as the Fere effect, the GSR is consistently influenced during motion sickness by perspiration symptomatology (9:14).

The electrodes used were fastened with fabric strips wrapped around each finger and secured with velcro. In this study, the electrodes were placed on the middle fingers of the left hand.

Electromyogram (EMG). The electromyogram is used to measure skeletal muscle tension which increases notably with stress (9:16). The device used was an Autogen 1100 amplifier/sensor with three surface-applied electrodes.

Electronystagmogram (ENG). The electronystagmogram is used to measure the sudden jumping sideways or up-down motion of the eyes when the semicircular canals are stimulated (23:645). This ocular movement is detected by

measuring the change in potential seen across both eyes. Each eyeball is polarized from the retina (negative) to the cornea (positive). Consequently, "electrodes placed lateral to each eye will measure a rightward glance as a right to left positive potential proportional to the magnitude of the rightward angle and a similar potential to a vertical glance if electrodes are placed above and below the eye" (9:15).

Pneumographs. Pneumographs are used to measure respiration type (abdominal or thoracic), character and rate (9:12). As a symptom of motion sickness, respiration can change in depth and rate in addition to shifting from diaphragmatic (abdominal) to thoracic (9:14).

The pneumographs were circumferential belts that employ strain gauges rather than variable capacitors (9:14). In order to detect changes, a frequency response of 0.05 to 5 Hz. was used.

Electrogastrogram (EGG). The EGG measures the electrical activity of the stomach. This electrical activity is a function of the stomach's contractile state. For instance, while retching, the distal stomach will contract and the proximal stomach will relax; the EGG is capable of detecting these changes in state (9:14).

The EGG is designed to study the stomach based on its general mixing contractions. The "Basic Electrical Rhythm" or BER of the stomach varies from about 1/min to 3/min with measurable surface smooth muscle potentials from 0.5 to 80

microvolts (9:15).

Two electrodes were used for the EGG; one was placed over the stomach in the left upper abdominal quadrant while the other, a reference electrode, was placed several inches away.

Electrointestinograph (EIG). The EIG detects activity of the small intestine. Previous research has established that early motion sickness symptoms, such as nausea, affects the tone of the duodenum (9:15). The BER of the small intestine is about 12/min at the duodenum; the BER decreases distally to the ileum where the frequency is 7-9/min (9:15).

The EIG provided a specific indicator of intestinal versus gastric gastrointestinal activity. The EIG design format was the same as the EGG. Its frequency response is 0.1 to 0.24 Hz.

The electrode was placed directly over the duodenum/jejunum region in the mid-abdominal area, with a reference electrode at the periphery of the abdomen. The EIG reference electrode was also the reference electrode for the EGG.

#### Data Collection and Storage Equipment

Strip Chart Recorders. Two eight-channel strip chart recorders were used to collect analog data on graph paper. Also, one dual-channel strip chart recorder was used to collect high rate EEG data. The eight-channel recorders

were Brush 200 models made by Gould Electronic. The dual-channel recorder was a Brush II manufactured by the Clevite Corporation.

The two eight-channel strip chart recorders were labeled A and B. In the final configuration, the recorders collected the following physiological parameters, from left to right:

Recorder A

1. Electrocardiogram.
2. Electroencephalogram.
3. Electronystagmogram (Horizontal).
4. Electronystagmogram (Vertical).
5. Photoplethysmograph (Facial).
6. Photoplethysmograph (Peripheral).
7. Electroencephalogram.
8. Electromyogram

Recorder B

1. Temperature.
2. Galvanic Skin Response.
3. Electrointestinograph.
4. Electrogastrogram.
5. Pneumograph (Thoracic respiration).
6. Pneumograph (Abdominal respiration).
7. Ballistocardiogram.

MASSCOMP MC500. The operating capabilities of the MASSCOMP MC500 computer system have been covered in the

thesis by Fitzpatrick, Rogers, and Williams. The major hardware addition to the system since the end of that thesis effort was a 166 Megabyte hard disk.

The computer system never worked properly. The probable reasons for the unsatisfactory performance and attempts to correct the flaws will be detailed in Appendix D.

Magnetic FM Analog Tape Recorders. To store physiological data conveniently for replay and analysis, these tape recorders were used on the last three test subjects. These recordings allowed analysis by a spectrum analyzer. Unlike the strip chart recorder and computer which allowed real-time observation of changes in the test subject, the recorders were useful only in a playback mode. Additionally, these recordings were limited in the number of channels that could be recorded in any one session.

## IV. Experimental Procedures

### Chapter Overview

This chapter describes the steps used to complete an experimental test session with a human subject. The preparation of both the equipment and the subject is outlined.

### Equipment Set-up

Equipment set-up consisted of three phases: connection of all electrical systems, power-up, and calibration/verification.

#### Electrical System Connections

1. Attached electrode leads to proper electrodes on test subject.
2. After subject was seated in chair, electrode leads were plugged into the proper connection from Circuit Board Box (A into A, B into B).

#### Power-up

1. Power was applied to both strip chart recorders, and the dual-channel recorder.
2. Power was applied to the EMG Autogen device on rear of chair.
3. Power was applied to the Circuit Board Box (NOTE: Electrodes must be connected to the Box prior to powering the Circuit Board Box).

#### Calibration/Verification

1. All strip chart recorders were run to ensure proper pen operation.



2. Adjusted gains on all equipment to get physiological readings into the desired sensitivity ranges. Proper sensitivity ranges were determined visually by observing the strip chart recorder channels and adjusted by using controls on the circuit boards mounted in the Circuit Board Box.
3. Calibration tests were performed on the following channels in the manner described. Results were noted on the strip chart recordings.
  - a. Nystagmus - subject was instructed to look up, down, right, and left.
  - b. Peripheral pallor - subject was instructed to raise and lower left hand.
  - c. GSR - subject would be given an unexpected startle stimulus (such as a sudden shout by an experimenter).
  - d. Facial Pallor - subject could perform a valsalva procedure where diaphragmatic pressure is applied against a closed glottis to force an increase in cephalic pulse pressure and thus cause flushing.
  - e. EMG - subject was instructed to tense the muscle mass under the sensor, e.g. shrug the shoulder.
  - f. Pneumographs - subject would take a deep breath.
3. MASSCOMP was configured as described in the DAADS User's Guide (Appendix D).

#### Subject Preparation

The preparation of a test subject consisted of administrative and experimental tasks.

Administrative Tasks. The administrative actions required were as follows (NOTE: Copies of the forms are contained in Appendix C).

1. Subject signed the Subject Consent Form.
2. The subject was given a verbal and written briefing,

and any questions were answered. Briefing included a demonstration of head motions.

3. Subject completed a Motion Sickness (history) Questionnaire.
4. Subject completed a Report of Medical History (AF Form 93).

Experimental Tasks. The pre-test activities were as follows:

1. A medical examination by a physician (Dr. William Czelen, M.D., for this study) which included:
  - a. Sudden stop vestibular test to check for nystagmus and normal vestibular function. This test involved spinning the subject at 14 rpm for approximately one minute, then stopping him suddenly. The subjects eyes were then observed to see if a normal nystagmus response was present. Experience showed that this step was most conveniently performed after the subject was thoroughly prepared for the test run (all electrodes attached, etc.).
  - b. Standard blood pressure, pulse, and respiration were checked.
  - c. Neurological/motor coordination tests were performed.
  - d. Any other tests deemed necessary or desirable by the attending physician were performed.
2. To physically prepare a subject for a test run:
  - a. Each subject's skin at electrode placement sites was thoroughly and vigorously scrubbed down with alcohol pads. Removal of the outermost layer of epidermis and oil where electrodes were placed was essential to assure good electrical contact throughout experimental run.
  - b. All electrodes were attached as shown in Figure 6 and Figure 8.
  - c. Chest and waist pneumographs were connected as shown in Figure 6.
  - d. Subject was assisted into chair.

- e. Subject was restrained with safety belts.
- f. Electrode connectors A and B were attached, as was the Autogen EMG connector.
- g. Sphygmomanometer was attached to right arm.
- h. Right ear was covered with hood.
- i. Final instructions were given on tape recorder operation.
- j. Test subject was blindfolded.

### Experimental Session

The experimental protocol for each session was as follows:

1. Subject and computer preparation as outlined above.
2. Subject Data Sheet was filled out (see Appendix C).
3. Sudden-stop vestibular test, as outlined above, prior to blindfolding of subject.
4. Subject was blindfolded, and the session tape recorder was started to record subject's voice inputs.
5. Sensors were adjusted as necessary to ensure a complete and accurate experimental session.
6. Chair was spun to an initial rate of 14 revolutions per minute. Chair speed was under the first protocol (see Chapter V) used the Planetary Yaw control knob to give up to 14 revolutions per minute. To obtain higher rotational speeds, the control console was reconfigured. The bottom of the left-side console has a row of six toggle switches. When the outermost switch on both the right and the left of the six toggles are moved to the "P. Yaw" position, chair rotation rate is controlled by the Roll Angle Control Knob on the center panel. This configuration allowed rotational speeds up to 30 rpm, although 25 rpm was the highest speed ever used. See Figure 4 to see the actual location of all the controls discussed.

7. Subject's vital signs were allowed to stabilize for approximately 2 minutes (no head motions were performed during this period).
8. Instruction was given to start tape recorder.
9. Head motions, randomly distributed between left, right, and forward tilts, were performed at two second intervals per the voice recording (longer intervals were used on some subjects as described in Chapter V).
10. Subject's physiological state was constantly monitored (blood pressure was checked when the physician considered it necessary).
11. Subject was asked for inputs on his condition, or inputs were given voluntarily (as the subject had been briefed to do). All inputs were noted at the appropriate position on the strip chart recorders.
12. At the end of six minutes, if the subject had not requested to stop or did not seem on the verge of doing so, the rotation rate was increased to 20 rpm.
13. Subject's state was continually monitored, and he gave verbal inputs voluntarily or upon request.
14. At the end of six additional minutes, if the subject had not requested to stop or did not seem on the verge of doing so, the rotation rate was increased to 25 rpm.
15. Subject continued to be monitored as described as described above. One experimental end point was reached at the conclusion of the last six minutes at 25 rpm. The other was a subject request to stop the spinning.
16. When the chair was spun down, a gradual deceleration of about 5 revolutions per minute<sup>2</sup> was used to avoid any unwanted provocative decelerative stimuli on the subject.

#### Session Termination

Session termination began upon the stop of chair spin.

The steps involved were as follows:

1. The subject sat quietly until all physiological

indicators returned to near pre-spin baseline values. The subject's input on how he felt was also important.

2. All power to the chair console was removed, to avoid accidental spin up.
3. After stabilization, the blindfold and ear cover were removed.
4. Insure data was stored on MASSCOMP.
5. The following equipment was then powered down:
  - a. Strip Chart Recorders.
  - b. Circuit Board Box.
  - c. Autogen EMG device.
  - d. Session tape recorder.
6. The seat restraints were removed.
7. The chest and waist pneumographs were removed.
8. The sphygmomanometer cuff was removed.
9. The A and B connectors were detached, as was the EMG Autogen connector.
10. The subject was CAREFULLY assisted off the chair.
11. All electrode leads were detached.
12. All electrodes were then removed from the subject.
13. Subject was released upon approval of physician.

## V. Experimental Results

### Chapter Overview

This chapter presents the observations and results obtained from the experimental data. The first section outlines general comments about the system and procedures. The second section presents observations of general trends in the data. The final section details specific trends for the physiologic criteria associated with the "big four" symptoms explained in Chapter II. These specific trends are based on an initial analysis of the data.

### General Comments

The system as a whole worked remarkably well. Some problems were encountered but they did not prevent accomplishment of the basic objective: to initiate a sensory conflict in human subjects by means of cross-coupled angular acceleration and to measure and record the physiological changes accompanying the onset of the evoked motion sickness response.

This section gives some general comments about how that objective was achieved and the problems that were overcome. It is divided into three areas: the data recording subsystem (computer, strip chart recorders, and tape recorder), the chair and sensor equipment subsystem, and the experimental procedures and subjects.

Data Recording Subsystem. Data recording was

originally going to be done solely by the MC500 computer. However, early in the program it was determined that the computer was not operating correctly due to hardware malfunction, software problems, or both. Appendix D details these problems. Two 8-channel paper strip chart recorders were placed in parallel with the computer to provide system back-up. This also provided realtime hardcopy output of the subject's physiologic reactions. This was particularly useful in determining the level of distress being experienced by the subject, as compared to the initial baseline levels, to assess the level of motion sickness. Due to the computer problems, these strip charts were the primary data collection devices for this effort. Some samples of the raw data obtained from the strip chart recorders are shown in Appendix B.

The strip chart recorders introduced their own set of problems, however. The recorders are old, and were not being used when acquired for this study. Consequently, the pens had to be refurbished and calibrated and the ink supply system carefully adjusted. Because of the sensitivity of the physiological sensor equipment, a serious ground loop interference problem developed whenever the strip chart recorders were plugged into a circuit other than that powering the MASSCOMP and chair. The outlets on the workbench provided a particularly noisy power supply. Once the power problems were identified and corrected, the

recorders worked well.

The use of a simple cassette tape recorder, placed in the chair near the subject to record the voices of both the subject and researchers, was effective. These voice recordings allowed experimenters to review each test session and verify test subject commentary and the timing of motion sickness symptoms.

The software program controlling data acquisition and storage (DAADS) also apparently had some problems. Program execution proceeded properly and the graphics display was correct for displayed data. However, when data collection was initiated the program ceased functioning after approximately one to one and one-half minutes. When the number of displayed channels was decreased from 12 decrementally to 7, the data collection time also increased incrementally until it was limited only by available file space; consequently, a potential buffer input/output problem was indicated. Before a software fix could be developed, tested and implemented, the hardware problems described in Appendix D appeared and continued until the time of this writing. Investigation by MASSCOMP service personnel disclosed that the operating system software was improperly installed initially, or was incompatible with this system's hardware options. The total effect of all the preceding problems on the DAADS program execution is difficult to judge, but it was probably detrimental. The version of the



DAADS program used for this thesis is listed in Appendix D.

Chair and Sensor Subsystem. The rotating chair, also called the Multi-Axis Tracking Simulator (MATS), was very effective in evoking a motion sickness response. Twelve subjects were run on the chair and all but three requested session termination in less than ten minutes due to severe motion sickness discomfort. The remaining three subjects never really developed severe symptoms, apparently because of individual conscious or unconscious compensatory actions. Initial results are discussed in detail in subsequent sections.

The MATS chair as configured by the previous thesis teams did not have the chair's canopy attached. The canopy was available and was tried on one run, in an attempt to control environmental conditions on the test subject. These conditions included body surface cooling due to air movement as the chair rotated (which could affect the peripheral temperature) and light pulses from wall-mounted spot lights (which could affect readings from the facial plethysmograph). In practice, the canopy was unsatisfactory for five reasons. The primary reason was poor ventilation. Although air vents were present on the canopy, there was no forced air circulation. Blower fans originally designed for the system were no longer present or available. Consequently, the outside weather conditions that contributed to the computer system failure also led to very

uncomfortable conditions in the enclosed chair. Additionally, when the subject began to perspire, humidity inside the chair increased significantly and exacerbated the problem. The second canopy-related problem was light infiltration through cracks and screw holes that caused a nauseating, visual stroboscopic effect. A better light seal was constructed, but then the ventilation problem increased. The third problem was maintaining effective communication with the subject. A two-headset transmit-receive radio was used but it allowed only one experimenter to talk with the subject. Also, the introduction of one more piece of equipment to an already heavily instrumented subject was difficult. The fourth problem involved insufficient visual observation of the subject by experimenters. The canopy made it very difficult to assess the subject's reactions and verify proper head motions. Finally, possible behavioral effects of enclosing a subject in a small space in an already stressful situation could not be determined. Consequently, for all subsequent runs, the canopy was removed.

The physiological sensors built and designed by Dr. Czelen worked extremely well. When system ground loop noise had been identified and eliminated, the detected signals were clear and accurate. Extreme care had to be taken when preparing the subject. For instance, each electrode location had to be vigorously scrubbed with an alcohol pad

to ensure good electrode-to-skin contact, which was essential for proper sensor operation. Also, electrode connectors had to be securely fastened and loose wires attached with tape to prevent noise or loss of contact.

The type of electrode used at a particular location strongly influenced sensor output. Use of an anatomically molded finger photoplethysmograph improved comfort and electrode contact. Similarly, an EEG electrode cap was superior to individually placed electrodes in both comfort and effectiveness. Facial electrodes for ENG recording were originally the NDM Corporation Silvon Stress test electrodes, which were quite effective but very bulky and occasionally lost contact when facial, especially forehead, sweating occurred. The Andover Medical "Huggables" electrodes were easier to attach and more reliable. Finally, the pneumographs worked reliably in all experimental runs.

One sensor which still needs improvement is the electromyograph. Although it worked well for most of the runs, it required different electrode attachment pads, separate electrode gel, a separate electrical lead, and another piece of equipment (Autogen 1100). Also, the electrodes had to be cleaned after each use. These various actions increased the time necessary for subject preparation and disconnection.

Experimental Procedures and Subjects. The techniques

used to elicit motion sickness and measure the physiological changes met with varying degrees of success. Since no standard experimental procedure was available, one had to be developed. This protocol evolved with experience, and took place in three basic phases.

In the first phase, the subject was directed via pre-recorded instructions to perform random direction head tilts at two-second intervals for two minutes. A three-minute rest period followed each period of head tilts, with resumption of the head motions occurring after the rest period. This on-off cycle would continue several times, and the run would end either at the end of the instruction period (about 15 minutes) or when the subject requested to stop. This protocol proved unsatisfactory because of a long period of time to onset of symptoms. A six-minute period of continuous head motions with a varying rest time was tried, but again the results were unsatisfactory because of the long period of time until symptoms were reported or observed. Experience showed that this protocol was not extremely provocative.

In the second phase, the two-second head tilts were continued but the rest periods were removed. This technique met with varying results, with two of the subjects lasting about 20 minutes without severe symptoms, while three lasted less than 10 minutes. This protocol seemed to clearly distinguish between motion sickness non-susceptible and

susceptible subjects, and was useful in that regard, but the data obtained from the non-susceptibles was lengthy and hard to interpret. This experimental procedure was the most frequently used of three basic protocols, and is the one described in Chapter IV.

In the third phase, the two-second head tilts were increased to 10 second motions. In this procedure, the head was tilted and held over the left shoulder, right shoulder, or chest for 10 second count, with a return to the upward neutral position for another 10 second count. This protocol apparently allowed significant stimulation of the vestibular system, since any stabilization that would occur during the 10 second hold period would be quickly jarred by the movement to a different position. Consequently, whereas the subjects in the two-second tilts lasted an average of 10.8 minutes of head motions before requesting to stop, the three subjects on the 10-second tilts lasted only 3.2 minutes.

The results of any particular protocol depend on the nature of the test subjects. Solicitation of volunteers was satisfactory, although it was a slow process and randomness could not be assured. Despite the imprecise method of obtaining test subjects, a relatively diverse pool of volunteers was obtained which included seven non-rated Air Force members, two rated Air Force pilots (including one fighter pilot), and one Dayton, Ohio television news reporter.

### Observations

In general, the subjects used in this study displayed "typical" motion sickness symptoms. That is, they showed the symptoms commonly reported in the literature and summarized in Table II. Some cautions are in order, however, when attempting to draw conclusions from this experimental data.

The first caution is that a small sample size was used. Although 12 subjects were run, the first two were used only for testing and troubleshooting the system. Of the remaining 10, the sample size varied between four and 10 depending on the physiologic sensor of concern. This is because on some experimental runs, especially the early ones, some sensors failed to work or worked erratically, causing the data for that particular parameter to be useless. However, for the major symptoms of facial pallor, coldness, sweating, and nausea, the sample sizes were 10, 9, 8, and 10, respectively.

The second caution is that the experimental protocol evolved throughout this project as explained in the first section of this chapter. The basic purpose of evoking a motion sickness response was met in all cases, but, as noted in Chapter II, if the rotational rates and head motion frequencies were changed, the type, severity, and rate of onset of symptoms could change. This means that comparing

symptomatology across the spectrum of protocols is difficult and potentially misleading. General trends can be identified but definitive conclusions must wait for larger sample sizes and a consistent standardized protocol.

The third caution is in reference to the experimental conditions. The environmental conditions in building 470 were mentioned earlier in regards to the computer system. The wide variation in environmental conditions had an unknown and unpredictable effect on the human subjects. This was a particular concern when measuring physiological symptoms of peripheral temperature, peripheral blood pulse volume, pallor, and galvanic skin response. Better environmental control would have improved the veracity of motion sickness symptoms due to the nauseogenic stimulus. Another point about experimental conditions is that the subjects could not be carefully controlled. Because AFIT students were solicited as unpaid volunteer subjects, strenuous controls could not be imposed. Thus, factors such as time since last meal, contents of that meal, level of fatigue, mental stress, recent alcohol consumption, and use of prescription or non-prescription drugs could be evaluated but not controlled. Again, the effect of these factors on motion sickness symptomatology is unknown.

With these warnings in mind, general observations were made. When the subjects were first spun up to protocol speed, brief responses were seen in the subjects. These

were often seen as the following:

1. Brief (5 - 10 second) onset of nystagmus, generally in the horizontal direction.
2. Sudden contraction in the intestines and/or stomach.
3. A deep inspiration.

Following the initial reaction, a short period of relative calm ensued until head motions began. With the second protocol (two second continuous head motions), two types of individuals could be identified. These types essentially correlated to the susceptible and non-susceptible groups recognized by earlier investigators.

The susceptible type generally demonstrated a short (one to two minute) latency period after head motion initiation before symptoms (changes in the character or appearance of the subject such as sweating or pallor) and physiologic changes (variations in the electrical signals observed) were observed. The susceptible individuals generally reported symptoms at or shortly after the physiologic changes began showing on the strip chart recorders. These symptoms would steadily increase to some level and would often appear to "avalanche." That is, the subject would report feeling "OK" one moment but in 30 to 60 seconds nauseous feelings would surge to an unbearable level. Symptoms would then usually persist for several minutes after cessation of head and chair motion, and in some cases would worsen before subsiding. Similar findings



have been reported by other investigators (2; 19; 46).

Stomach awareness ("churning") and sweating ("clammyness") were two of the most commonly reported early symptoms and were evidenced by sudden amplitude increases in the EIG and EEG recordings. The GSR recordings (indicating perspiration) usually did not show a definitive change correlating to the symptomatology. They generally showed, however, a steady increase in skin conductivity which indicated increased sweating. Other overt symptoms included dizziness, flatulence, tingling in the extremities, belching, and a general feeling of malaise. These symptoms were also difficult to correlate to the electrical signals, although the gas symptoms generally occurred at the time of maximum gastric and intestinal activity. Observations by the investigators included facial (especially forehead) sweating, increased pallor, and occasional apparent mental confusion manifested by an inability to follow the simple head motion commands on the instruction tape recorder.

The non-susceptible group of individuals were characterized foremost by the length of time necessary for symptoms to develop and become severe enough for session termination. Two subjects (subjects 5 and 9) had session elapsed times of 17 and 21 minutes, compared to the average for the other 8 subjects of 6.8 minutes. Further, the non-susceptible subjects showed a pattern of symptom appearance, followed by symptom abatement, and then reappearance. This

pattern would repeat for several cycles with gradually increasing symptom severity. Bock cited a study done by Reason and Graybiel in which a similar pattern of oscillatory discomfort punctuated with periods of transitory improvements was observed (2:776). Background data on these subjects and post-run debriefing revealed possible reasons for the low susceptibilities to motion sickness. In one case (subject 5), the subject had undergone informal training in meditation and relaxation techniques. This subject reported using these techniques in an apparently successful attempt to control the onset of motion sickness. In the other case, the subject was an Air Force fighter pilot with hundreds of hours of experience. He claimed not to have consciously attempted control of the sickness, but it is possible that he had pre-established automatic control mechanisms that intervened and compensated for the increased stimulus. In other words, this subject probably subconsciously used adaptive mechanisms to control motion sickness.

Overall, motion sickness responses were evoked in all the test subjects although there appeared to be a clear distinction between susceptible and non-susceptible individuals. The next section will look at specific trends in the symptomatic areas of pallor, sweating, temperature, and nausea (EIG and EGG). It will also briefly address some initial results based on a cursory analysis of the magnetic

tape recordings.

### Data Analysis

A very large amount of data was collected in this project. The 12 subjects represented a total experimental run time of 303 minutes. At an average sampling rate of 10 Hz. on 15 separate channels, this amounts to approximately  $2.73 \times 10^6$  bits of data. Originally, this data was to have been collected on computer disks. This would have allowed smoothing and sampling algorithms to be run. The data could then have been statistically analyzed for inter- or intra-relationships. However, when the MASSCOMP system failed another approach had to be developed. The first method was to collect data on paper strip charts as explained earlier. This allowed real-time observation of the data signals, but the records obtained were not conducive to in-depth analysis. Data collection on analog (FM) magnetic tape was the second method employed. This method did not allow real-time observation of the data, except for one or two channels on an oscilloscope. It did, however, allow for replay and automated analysis on a spectrum analyzer. Unfortunately, a supply of magnetic tapes was not immediately available, and thesis time constraints required data collection to proceed. By the time magnetic tapes could be procured, only the last few subjects remained to be tested. Consequently, the bulk of the data analysis had to be done by manual measurement of

the electrical signal tracings on the paper strip charts. A cursory analysis was done on the few magnetic tape recordings with the understanding that the data was not statistically significant due to the small sample size. This section describes the results of the manual strip chart analysis and related findings from the initial analysis of the FM tape recordings.

As explained previously, the amount of data collected was very large. Because of that fact, and the complexity of some of the signals, all the recorded channels were not analyzed. It was also recognized that some channels were more important or more informative than others. Consequently, the recordings of EKG, peripheral photoplethysmograph, EMG, and ballistocardiogram were not analyzed. This is not to say that these parameters are unimportant; it is just that their importance has yet to be firmly established. The recordings of basic EEG, ENG, and pneumographs were not analyzed by strip chart analysis but a limited number were studied by spectrum analysis. The spectrum analysis, performed by Dr. Czelen, is presented in Appendix A.

The channels that were selected for manual analysis included pallor (facial plethysmograph), temperature, GSR, EIG, and EGG. Spectral analysis was also performed on EIG and EGG for subject 12 and is presented in Appendix A. These five parameters were chosen because they most closely

measured the onset of the "big four" motion sickness symptoms of pallor, cold sweating, nausea, and vomiting. In this study, vomiting was not used as an experimental end point, and was not observed. However, reports from a number of researchers, notably Crampton and Graybiel, have noted that vomiting is almost always preceded by nausea. Thus, measuring the physiologic indicators of nausea is tantamount to measuring the precursors of vomiting.

The technique used for manual analysis was the following. Because the length of time necessary for symptoms to develop and progress varied from subject to subject, a common yardstick was required for measurement. The one chosen was the provocative period of head motions, from the beginning (when taped instructions started) to a common end point (when each subject requested to stop). This period was then divided into six equal increments so that a midpoint and several intermediate points would be represented. Additionally, one increment before and two increments after the provocative period were plotted to show pre-sickness and post-sickness responses. Including the zero (beginning) point, this method generated 10 equally spaced data points along a common axis for all subjects. For pallor, temperature, and GSR, the specific value, normalized to a common scale, was used. EGG and EIG, on the other hand, required frequency measurements and demanded representative values measured over some time interval. The

interval chosen was the 30 second time span immediately preceding each data point. Frequency in cycles per minute (cpm) was measured as double the number of wave peaks in the 30 second interval. With a common BER of 3 cpm, shorter interval was not practical and with provocative periods often as short as two to three minutes, a longer interval could not be used.

To cope with the physiologic parameters that had no established reference point such as pallor, the subject had to act as his own control. This was accomplished by selecting the smoothest section of the graph immediately prior head motion and assuming that it represented that subject's stabilized baseline value for that parameter. Subsequent deviations above or below that value were then represented graphically as percentages of the baseline. Prior to calculating the percentages, the values for all the subjects were normalized to a common scale, in this case 0 to 50 was the scale used.

The techniques described above were very effective in reducing the amount of data to a manageable size, and in developing common ordinate and abscissa scales for all the subjects. These techniques were applied to the five physiological parameters described above. Each of these five is examined below.

Pallor. As explained in Chapter III, pallor is a commonly reported symptom of motion sickness and is believed

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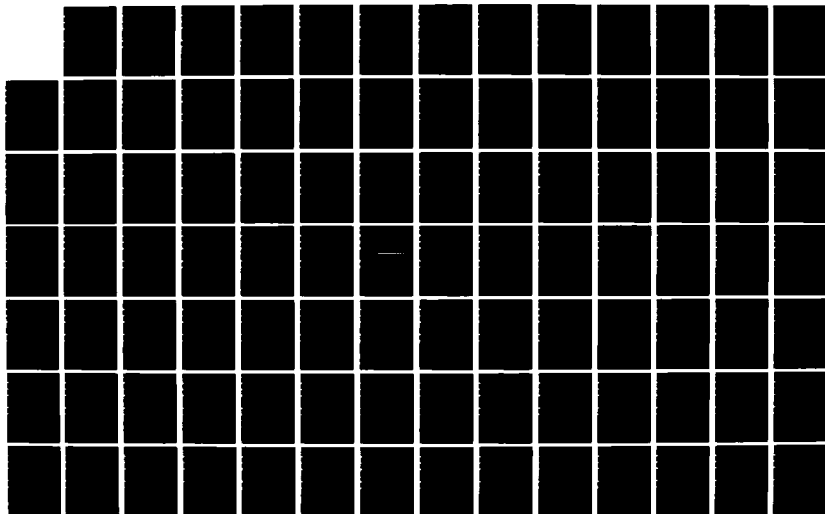
AN ANALYSIS OF POTENTIAL PREDICTIVE PARAMETERS OF  
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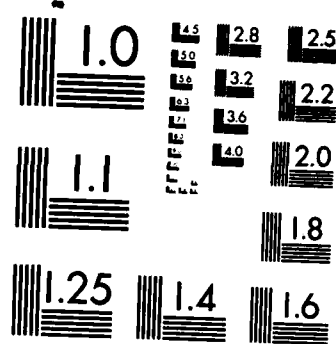
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MICROCOPY RESOLUTION TEST CHART  
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by some researchers (7:507) to be the only reliable predictive agent. This study essentially confirmed that pallor increases in the majority of subjects and generally precedes the onset of severe motion sickness. These data are presented in Figure 9. The data indicate that three patterns of symptom progression may be discerned although there is one common feature. The common feature is that there is usually a slight increase in pallor just prior to the beginning of head motions, followed by a brief decrease (flushing) upon initiation of head motions. The initial increase was possibly due to the beginning of chair rotation. The first pattern (shown by the lower curve in Figure 9) is that some subjects continue to flush after beginning head motions until approximately the fourth interval. These subjects then get paler as motion sickness progresses until they are at or slightly above their original level of pallor shortly after cessation of head motion. This group represented 30% of the total.

The second identifiable pattern is shown by the middle curve in Figure 9. The subjects in this group showed a relatively steady increase in pallor after the initial flushing. They continued to increase even after stopping head motions until at the eighth interval they were approximately 16% paler than at the beginning. This group was the bulk of the subjects, representing 50%.

The third group demonstrated a relatively large

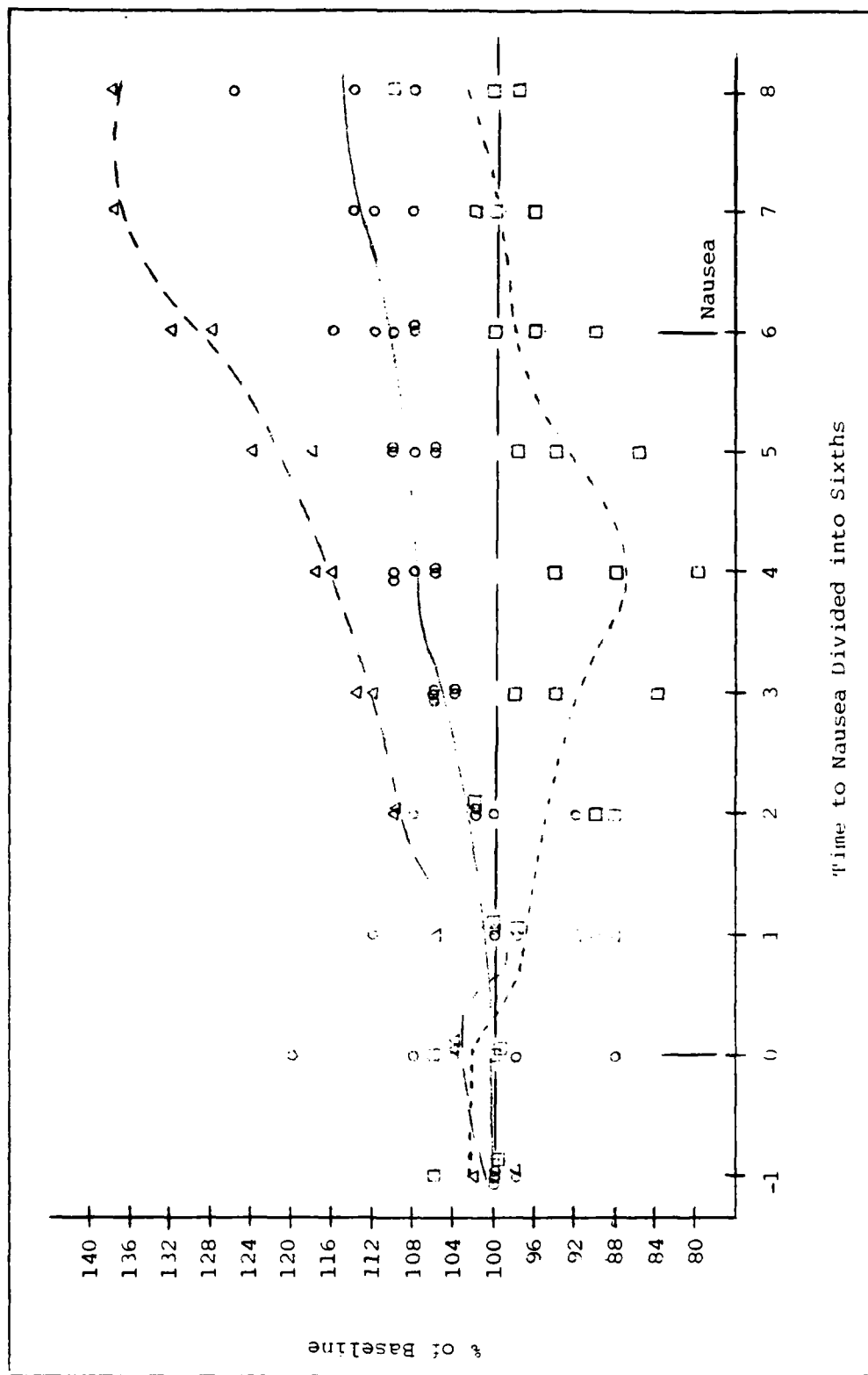


Figure 9. Pallor

increase in facial pallor. The two individuals in this group showed approximately 30% to 40% increases in pallor over their baseline values. One of the two had the characteristic initial flushing while the other steadily increased in pallor.

These data indicate that increasing pallor appears to be a reliable precursor of motion sickness in the majority of subjects. However, the reader is cautioned that many other stimuli besides cross-coupled angular acceleration, and subsequent motion sickness, can cause pallor. This same statement may be made for each of the physiologic indicators. Thus any one, or even several, cannot be taken as unequivocal predictors of motion sickness.

Temperature. For temperature, 8 data records were obtained. The measurements were taken exclusively during the provocative period for simplicity. The baseline value is the data point at the start of head motions (0 on the time scale). As mentioned earlier, temperature readings were normalized to a arbitrary standard scale so that the baseline value for each subject was equal. All data points were scaled along with the baseline value. Each data point obtained was then compared with the subject's baseline, and a percentage representing the data point's relationship to the baseline was calculated. EXAMPLE CALCULATION: A sample raw baseline point equals 22 divisions on the strip chart. A sample raw data point equals 23 divisions. Using a

normalized baseline value of 50, 28 would be added to both 22 and 23, leaving values of 50 (baseline) and 51 (data point) respectively. Dividing the data point into the baseline, a percentage of 102% was obtained, and this value was used for graphing purposes.

Most subjects changed with time in an essentially linear fashion. Two subjects, however, were somewhat more cyclical than linear. Although the sample size was extremely limited, four possible trends were noted with two subjects representative of each trend, as shown in Figure 10. The representatives of each trend are distinguished by a separate symbol on the graph (circles, triangles, squares, and crosses).

The most prominent trend is graphically represented by the circles. These subjects, 5 and 9, dropped sharply and steadily from the moment head motions started. Interestingly, these subjects were also the ones noted as apparently non-susceptible to motion sickness.

On the other end of the scale, represented by triangles, two subjects (6 and 11) rose quite steadily from time 0. They did not rise as sharply as subjects 5 and 9 dropped, but the trend is still pronounced. Both subjects terminated at the 108% level over baseline.

The squares, subjects 7 and 12, dropped in temperature. The drop was not as steep, however, as that experienced by subjects 5 and 9. Also, both subjects in this temperature

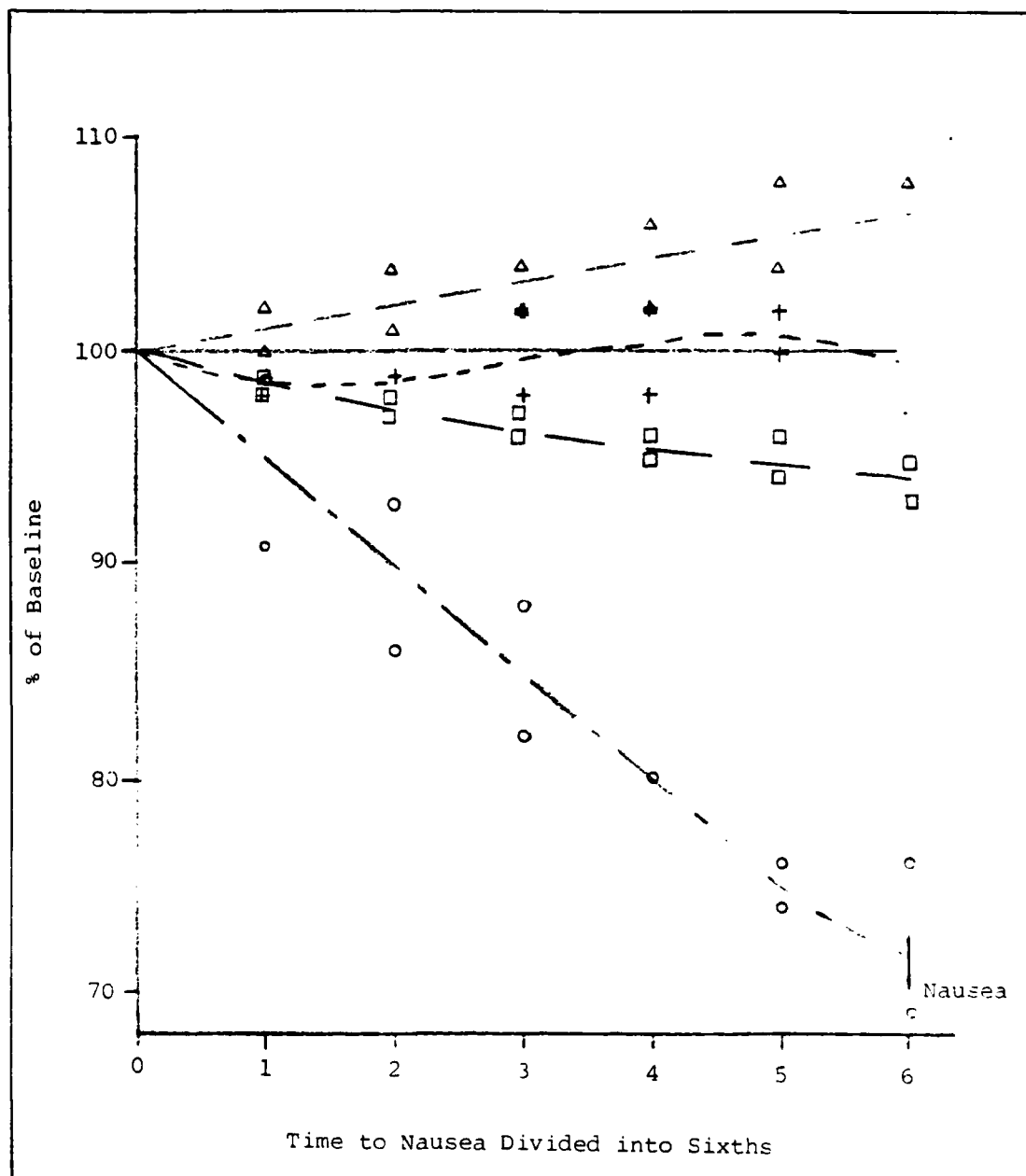


Figure 10. Temperature

drop may be considered susceptibles from the results of this study, unlike subjects 5 and 9.

Subjects 8 and 10, represented by crosses, are less linear than the other subjects - they tended to cycle around the baseline level. Subject 8 first fell in temperature, then rose above baseline and remained level for a time, only to fall sharply to a point below baseline upon nearing the end point. Subject 10, on the other hand, dropped slowly then rose steadily to a point above baseline when nearing the end point.

Again, these trends were based on a very small sample size and a very elementary analysis. Only further in-depth study will reveal if there is any significance to these results.

GSR. Galvanic skin response was explained in Chapter III as the change in skin conductivity to a low level AC electrical signal. Figure 11 shows that the majority of test subjects did show a significant change in conductivity. The upward direction on the graph represents increased conductivity as a percentage of the baseline level. Increasing conductivity is closely associated with body perspiration. Thus Figure 11 indicates that most of the subjects had increased sweating as motion sickness advanced. This objective conclusion was supported by observation and subject reports during the experimental runs. Most of the

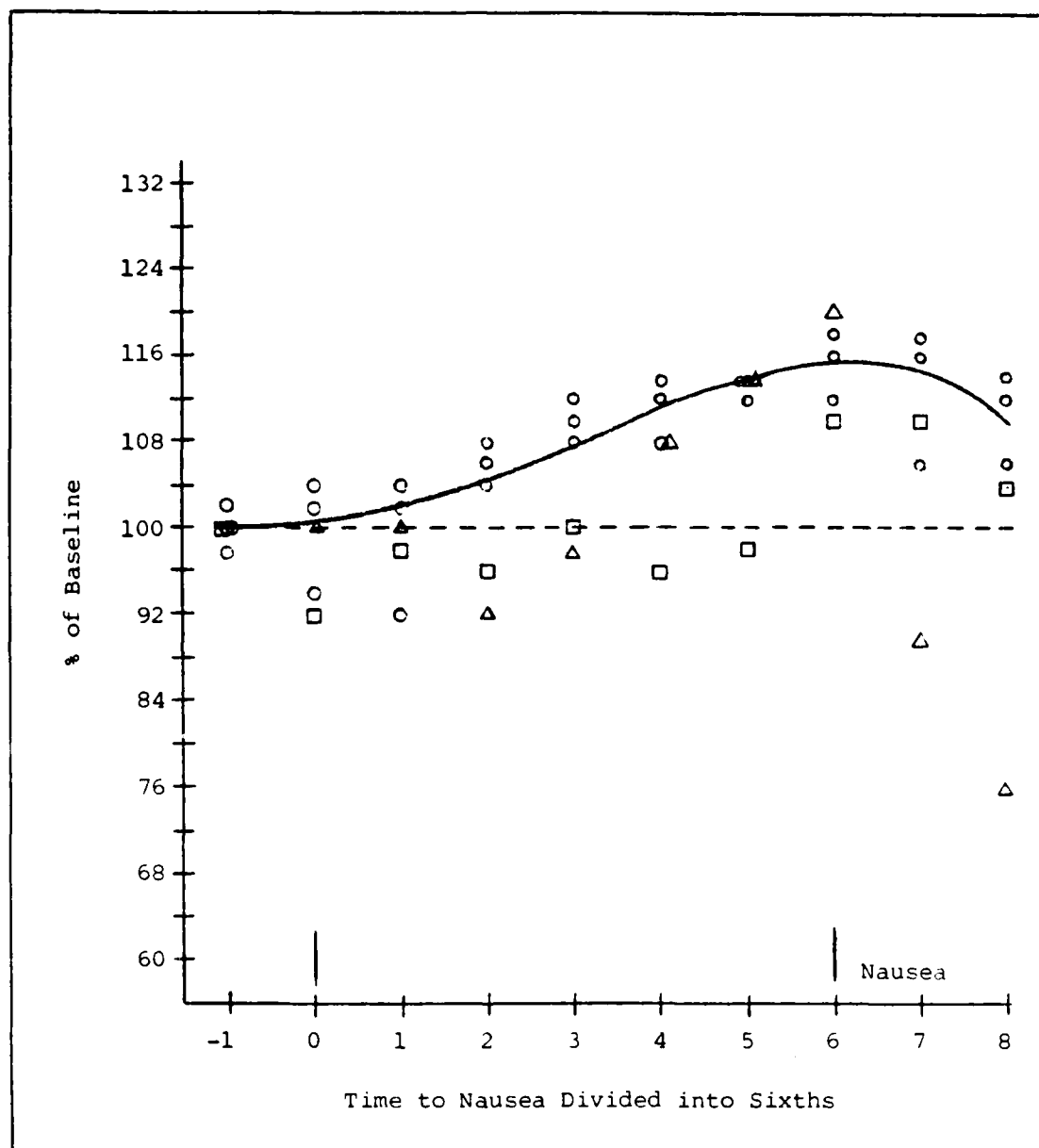


Figure 11. Galvanic Skin Response

subjects reported symptoms of clammyness or sweatiness during the runs. Again the largest deviations from the curve corresponded to the two relatively non-susceptible subjects. Both of these subjects had conductivity values that were at or below the baseline until the midpoint of the provocative period. At that point, Subject 5's GSR (triangles) began to rise quite sharply. He reached a maximum point at approximately 20% above the baseline value and then showed a rapid fall in GSR. Subject 9 (squares) showed a similar sharp increase from the fifth to sixth time intervals followed by a decrease in the eighth interval. If the graph was carried out one more interval, it would show that this subject's GSR dropped to the 92% level. These two individuals appeared to demonstrate a compensatory reaction to the motion sickness stimulus. Whenever the symptoms exceeded certain limits, possible adaptive mechanisms reacted to bring the symptoms under control. The responses appeared to overshoot the baseline value however, resulting in larger excursions of GSR values for the subjects.

FIG. The electrointestinogram measured the level of activity of the small intestine. This physiological parameter, and stomach motility or tonus described in the next section, are the best indicators of the onset of nausea and vomiting. As explained in Chapter II, most researchers have noted a close correlation between the onset of motion sickness and gastrointestinal changes, an observation



confirmed in this study. Figure 12 presents amplitude data for the EIG. Frequency data are presented in Figure 13.

Amplitudes. Amplitudes of the EIG signals showed a large increase for the majority of subjects as motion sickness symptoms developed. These amplitude increases ranged upwards of nearly fourteen-fold, with the maximum average increase approximately 400%. The graph also shows that the maximum average increase occurred at time interval four. This is the point at which most subjects began to experience motion sickness symptoms, particularly stomach awareness. But as the symptoms worsened, the intestinal activity apparently decreased until head motion termination at time interval six. The increase in activity after interval six may be the result of chair deceleration, but this can only be determined by further research.

Frequency. The frequency data shown in Figure 13 was not as conclusive as the amplitude data. The basic electrical rhythm (BER) of the small intestine in the area of the duodenum is usually 11 to 12 cycles per minute (23:796). This frequency was observed for the majority of subjects for the duration of the experimental runs. A very slight frequency increase might be noted in the fifth and sixth time interval, but this could have been due to motion artifacts. A serious concern of the current study is in relation to experimental control comments made earlier. The volunteer subjects could not be stringently controlled for

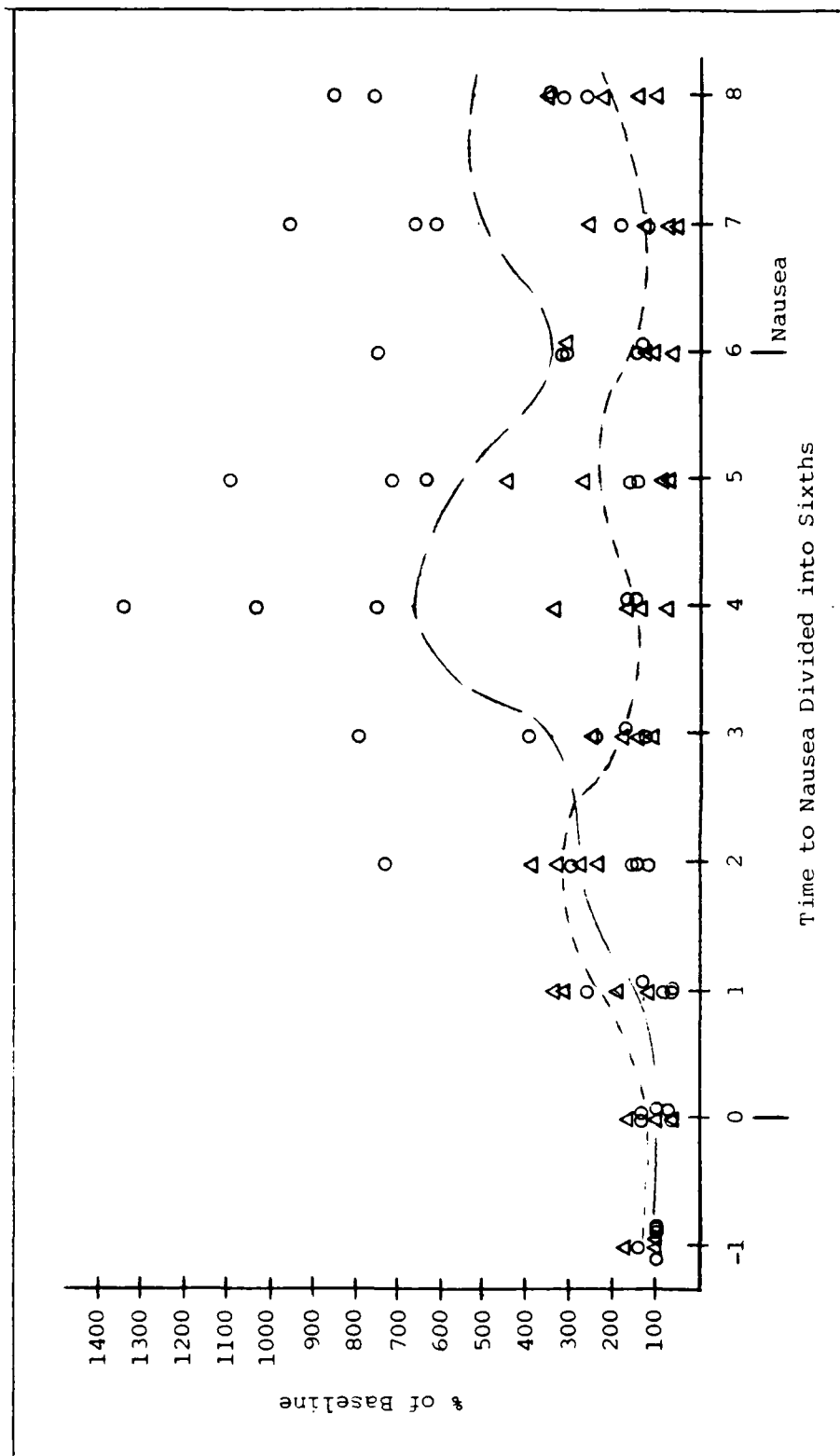


Figure 12. EIG Amplitude

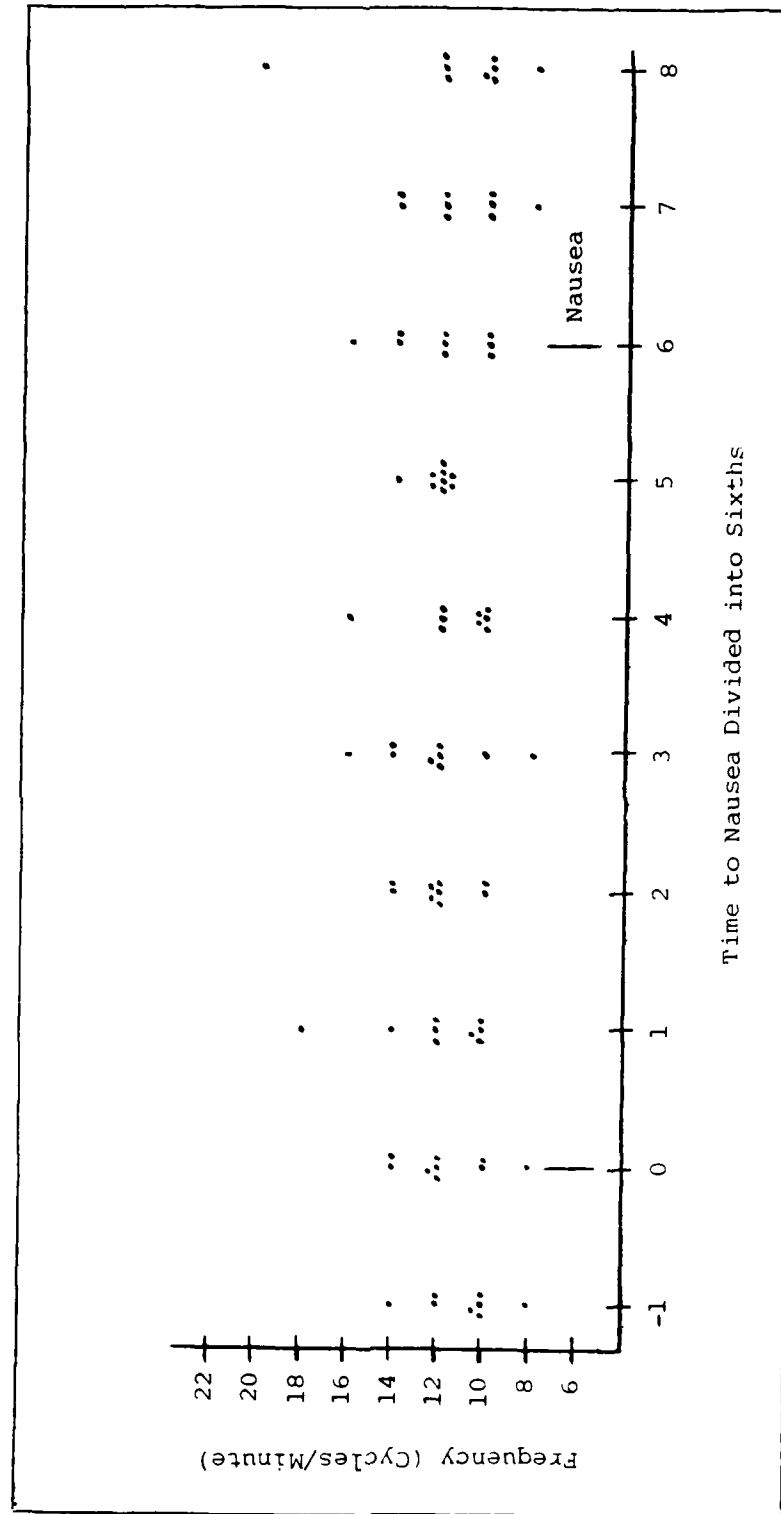


Figure 13. EIG Frequency

all variables. A major factor for gastrointestinal activity is the amount of food in the alimentary tract. Previous researchers have noted that introduction of food into the tract increases the amplitude and frequency of contractions (1:914). Most of the experimental runs for the current study were performed shortly after normal lunch hours but a number of subjects reported not having eaten since the morning, and in one case since the previous evening. These factors may have influenced the results.

The Fast Fourier Transform (FFT) spectral analysis performed by Dr. Czelen and presented in Appendix A supported these findings. Figure 16 indicates increased EIG amplitude with little or no increase in frequency.

EKG. As with the EIG, two separate aspects of the EKG results were briefly analyzed: the amplitude and frequency. Amplitude information shown in Figure 14 provided some interesting results; frequency data, as displayed in Figure 15, showed no discernible trend and may have been affected by factors previously discussed under EIG frequency concerns.

Amplitude. Seven test subjects provided usable data regarding any amplitude changes during the course of the provocative period. The baseline amplitude shift on all subjects, calculated from a quiet period of each subject on the strip chart, was one chart division (1mm). Any changes in the peak-to-valley distance above or below this one

division level were noted. The period where these amplitude shifts were observed was the 30 second period immediately preceding each one-sixth time division. For completeness, additional readings were taken one-sixth interval before time 0 and two one-sixth intervals after the end point.

Three major but crude trends could be noted. One trend involves the non-susceptible subjects (5 and 9), while the remaining trends involve the susceptibles (6, 8, 10, 11, 12). The two non-susceptibles (squares) were generally characterized by significant amplitude increases before the third time interval (as opposed to after the third time interval for non-susceptibles), with a gradual return to baseline at the time the end point was reached. Subject 9 showed a rapid rise in amplitude at time interval seven; however, this subject agreed to be stopped suddenly from 25 rpm so his reactions could be observed, and the possible result was this amplitude shift. Other volunteers were decelerated gradually. A probable explanation as to why the amplitude shift occurred earlier for non-susceptibles relative to the susceptibles is related to the variable time scales. The one-sixth time intervals are dependent on how long the subject withstood the provocative stimulus - the longer the ride the wider the intervals are spaced. In fact, the average time of onset of physiological indicators occurred about the same number of minutes after the provocative stimulus began for both the non-susceptibles and

susceptibles, but since the non-susceptibles rode longer the onset of symptoms appeared early relative to the end point. Still, the non-susceptibles appeared able to consciously or unconsciously ameliorate the amplitude shifts.

The susceptibles, unlike the non-susceptibles, generally appeared unable to control the amplitude shifts (if the shifts occurred at all). Two trends may be discriminated. One, shown by circles, involved two subjects (8 and 12) that showed very little amplitude shift throughout an entire run. Subject 12 did have a large increase immediately following the end of head motions for unknown reasons; Subject 8 showed little change for the duration. The second group, displayed by triangles, involved subjects 6, 10, and 11 who each showed widely fluctuating amplitude shifts (greater than 1000%) during the provocative period. Subject 11 calmed immediately after stopping head motions, while Subjects 6 and 10 continued fluctuations for some period of time after head motion stop. Subject 10, whose amplitude peak was actually the highest after the stop of head motions, was requested after having been stopped from spinning, to resume spinning and do one or two more 10 second motions. This subject was able to do only one motion before severe nausea appeared, and was the only test subject of the 12 to come near vomiting.

The three major groups are only an initial interpretation of the data collected. Further studies and

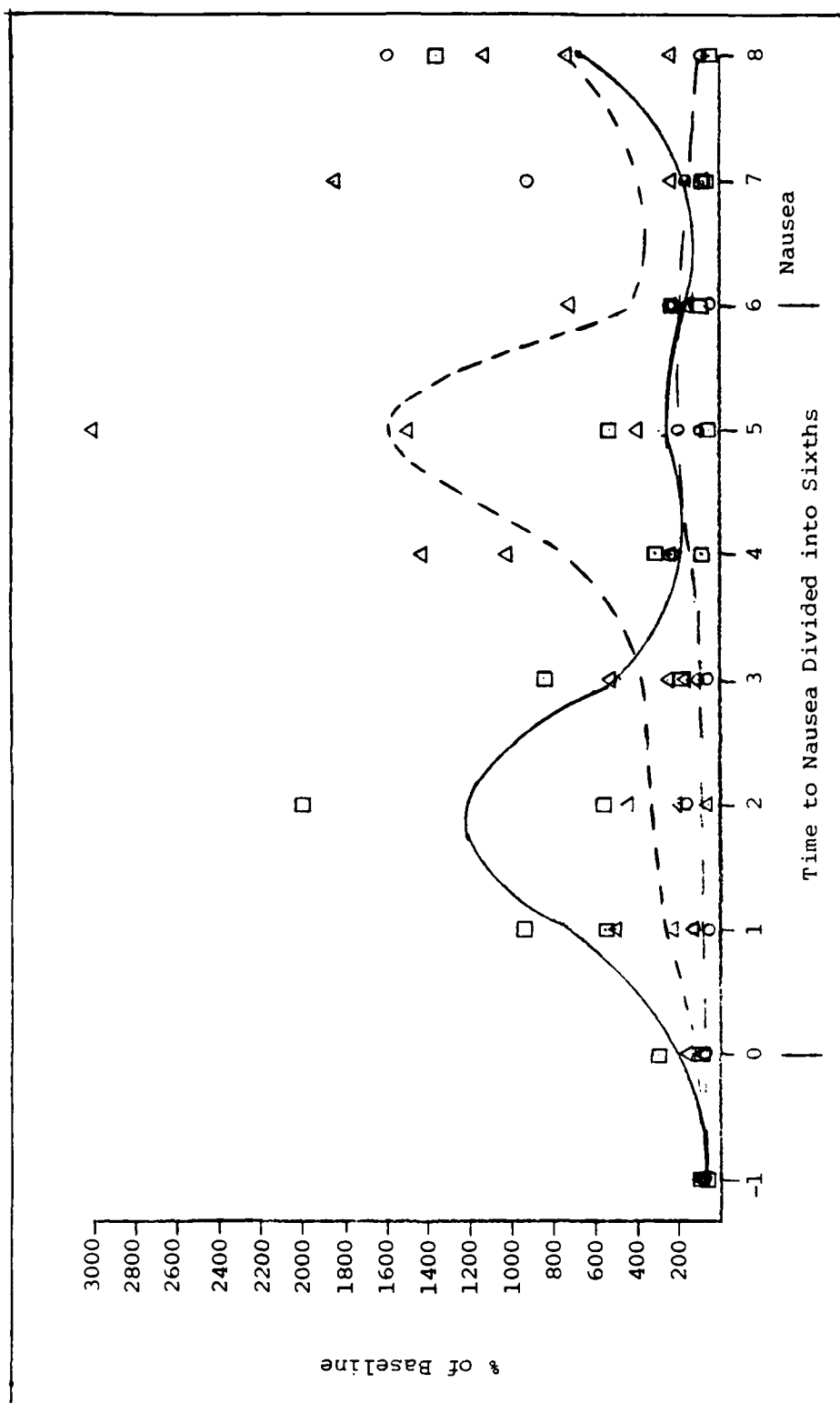


Figure 14. EGG Amplitude

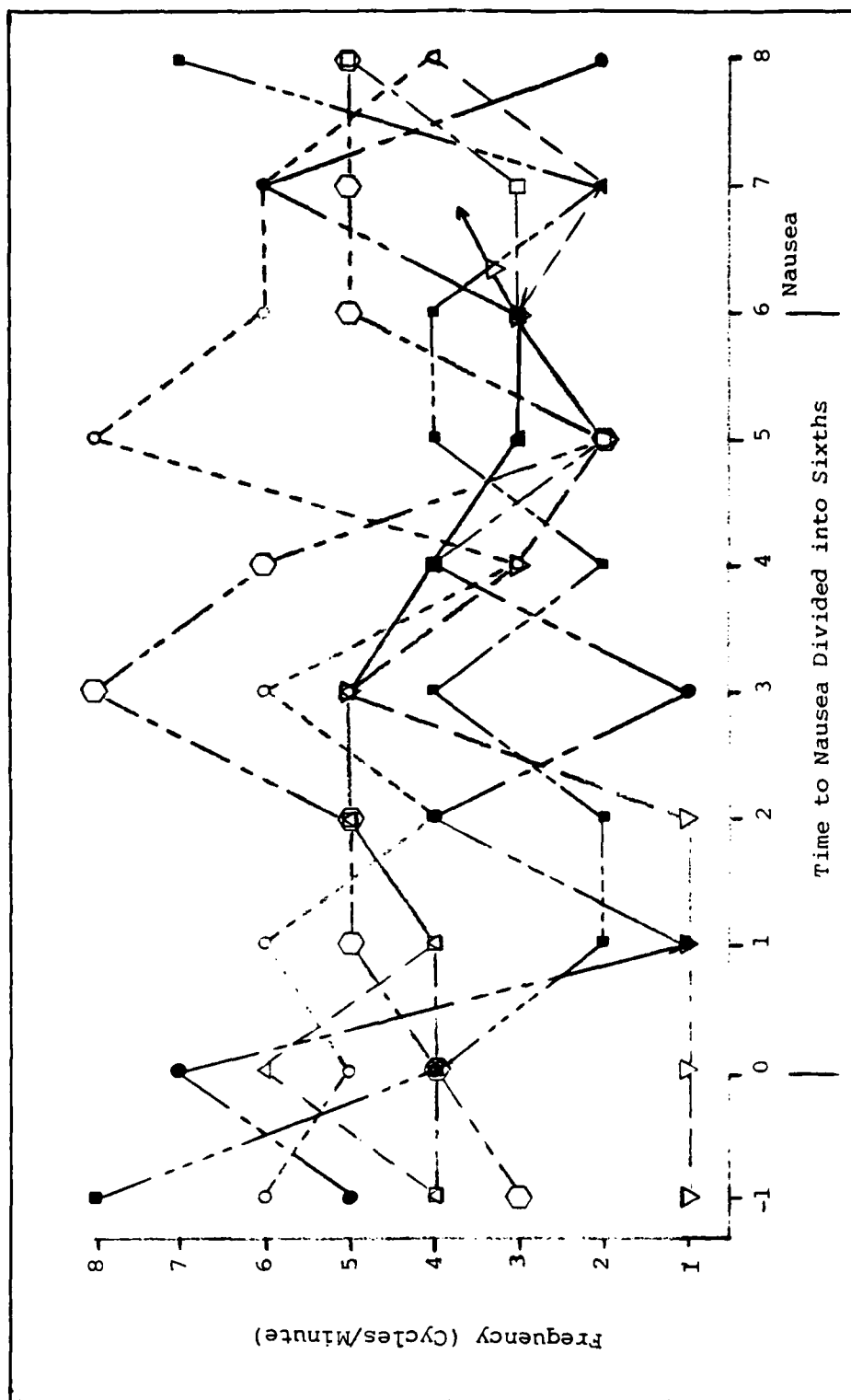


Figure 15. EGG Frequency



analysis are required to confirm or deny the validity of the results discussed.

Frequency. As for EIG, the results obtained were inconclusive. Frequency was measured peak-to-peak, and the commonly reported BER of 3 cycles per minute (49:1074) was not consistently observed. Fluctuation of frequency was seen in all subjects; however, no common trends or repeating patterns could be discerned. A shift in frequency similar to the type discussed by Stern and others (49:1075) was seen in subject 12 in both the manual analysis and after FFT spectral analysis. Further data reduction of this type may prove worthwhile.

As stated frequently throughout this chapter, the results obtained were based on very cursory analysis. Some trends were clearly evident in the data, as described, but much more research will be needed to confirm these findings and provide a solid statistical base. The next chapter will summarize these trends and present recommendations for follow-on research.

## VI. Conclusions and Recommendations

### Chapter Overview

This chapter finishes the thesis by presenting the conclusions derived from the study. It also outlines recommendations for system improvements and better techniques for follow-on studies and analysis.

### Conclusions

The conclusions obtained from this project fell into three main areas: system effectiveness, data collection and analysis, and applications to further research. Each of these areas is discussed below, with emphasis on the second.

System Effectiveness. As detailed in the previous chapter, the system worked. That is, it was effective in eliciting a motion sickness response in all the subjects tested. The electrical transducers designed and built by Dr. Czelen were effective and accurate in measuring physiologic changes. The strain-gauge pneumograph sensors were a large improvement over the previous variable capacitance-type sensors. With the exception of the MC500 computer, the recording subsystem was effective in recording each subject's responses to the motion stimulus. However, for future in-depth analysis, particularly statistical work-up, the computer system is essential.

Data Collection and Analysis. This system allowed qualitative and quantitative data collection on subjects in

the "trans-sickness" phase of motion sickness. This enabled comparisons to be made with the onset of symptoms. These comparisons resulted in the following statement: specific criteria were identified as possible predictors of motion sickness. These criteria included the following and apply in general to the susceptible type individuals:

1. A moderate or rapid increase in facial pallor, usually after a slight flushing, to a level of 8% to 20% over the baseline value.
2. Generally, a steady increase in GSR to a level of 12% to 16% over baseline.
3. A significant increase in intestinal activity, usually seen as a 600% to 700% increase in EIG amplitude.
4. A large increase in intestinal activity, seen as a several-fold jump in EGG amplitude.

Finally, two distinct types of individuals were identified in terms of motion sickness susceptibility. The procedures used in this study, especially the second protocol, were useful in identifying susceptible versus non-susceptible subjects to the motion sickness stimulus.

Applications to Further Research. The conclusions from this study are preliminary, but they lay the groundwork for more detailed research with established procedures and proven equipment. The 12 subjects used in this project showed some definite trends in physiologic changes but a larger sample size is needed to support or refute those trends.

## Recommendations

This section presents suggestions for future researchers using the computerized Biophysical Data Acquisition System. It is divided into sections covering the equipment, procedures and subjects, and the data analysis.

Equipment. Three main equipment systems are covered in this section: MC500 computer, the MATS chair and its control console, and the physiologic sensing equipment.

MASSCOMP MC500 Computer. The MC500 system had many problems, as outlined earlier and in Appendix D. The most important recommendation - to get the system working - has recently been done. However, the computer is now working in a relatively benign environment in building 640. If it is moved back to building 470, environmental problems will again impact its performance. Thus, for a reliably operational system, the entire BDAS system must be moved to appropriate quarters in building 640.

The computer software still requires debugging. Particular emphasis should be placed on the use of input/output buffers in the Cllctdata [sic] module, and specifically in the Collectdata module. It must be realized that the Programmable Digital Collection Equipment (PDCE) and Subsystems Interface Circuit Module (SICM) described in the Fitzpatrick, Rogers and Williams thesis (12) are no longer part of the BDAS. Thus, only the parallel (analog)

mode of data collection is functional.

Further improvements to the software should include a capability for user-controlled choice of storage medium (i.e., 166 Megabyte hard disk, 27 Megabyte hard disk, floppy disk, or magnetic tape). The storage device is now controlled by the program software. Another improvement would be to allow realtime insertion of event markers into the data, to facilitate later analysis. Ideally, these markers would incorporate some means of code to identify their meanings.

MATS Chair. The chair needs three basic improvements. The first is to remove the equipment rack from the back of the chair. The equipment rack unbalances the chair and causes excessive wear on the main bearings which creates a potentially dangerous situation for the human subjects and equipment, should the main bearings seize.

The second improvement is to enable the pitch and roll function of the chair. This would allow cross-coupled angular accelerations without the need for head motions. Head motions cause noise artifacts to enter the data, occasionally cause electrode dislodgement, and distract the subject from recognizing or reporting motion sickness symptoms. Removal of the equipment rack would facilitate enabling the pitch maneuver.

The third recommendation is to re-incorporate a

microcomputer control system into the command console to allow precise, reproducible chair motions. The left panel of the control console had a microcomputer attached when the system was used by Aerospace Medical Research Laboratory.

Another recommendation involves improving the historical recording of each run. A videotape of each test run would assist in assessing a test subject's overt responses and allow accurate correlation of physiological data records with subjective responses.

Physiologic Sensors. Although all the sensors worked very well, some suggestions are offered for improvement. First, the EMG sensor should be redesigned to use an integrated circuit board rather than the Autogen 1100 and disposable electrodes. Consequently, the equipment rack could be removed with the advantages discussed above.

Second, an input device is needed so that the subject could make a subjective evaluation of his self-assessed level of motion sickness and input it into the data stream on a separate channel. This would provide additional data for future biofeedback applications.

Third, the method of sensor calibration and adjustment should be changed. With the circuit cards current placement, the chair must be stopped for adjustment and calibration. An unplanned stop of the chair introduces an undesirable additional variable into the motion sickness stimulus. If sensor adjustments could be automated,

accurately preset, remotely controlled, or otherwise moved off the chair this variable would be removed.

Procedures and Subjects. The major recommendation of this section is that more stringent control of the experimental conditions must be employed. These conditions include:

1. Air temperature.
2. Humidity.
3. Time since last meal.
4. Alcohol consumption.
5. Prescription or non-prescription drug use.

Only by controlling, or at least evaluating, these conditions can reliable comparisons be made between subjects.

The experimental procedures must also be more consistent so accurate data analysis may be performed. The sudden stop vestibular test performed on all subjects must be done at least 15 minutes in advance of the experimental run to allow any effects of the vestibular disturbance to dissipate before the experimental measurements begin. After initial spin-up, a suitable stabilization period of at least 15 minutes is necessary to establish baseline values for physiological parameters. During the run, a precise protocol must be followed to allow valid comparisons between subjects. Following the nausea end point, physiologic parameters must be allowed to return as close as possible to

baseline values to measure symptom abatement.

Data Analysis. Computer analysis programs must be developed or purchased for the BDAS. Due to the large volume of data, computer analysis is the only feasible method of getting accurate statistical results and time series and/or cross correlation analysis.

The equipment and procedures presented in this thesis form the basis of a well integrated experimental system with a proven capacity to produce valuable results. This tool must be used to the maximum extent possible to expand knowledge of the etiology, prevention, and treatment of motion sickness.



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## Appendix A

This appendix presents charts and graphs obtained from analysis of the raw data. The spectral analysis graphs were re-drawn from graphs obtained from Dr. Czelen. The procedure used by Dr. Czelen was the following. Subject test data for the particular channel of interest, collected on FM magnetic tape, was played back through a Brush II dual-channel strip chart recorder. The pre-, trans-, and post-motion sickness periods were correlated to segments on the tape by means of the tape counter. The tape was then rewound and the segment of interest was played into an FFT Spectrum Analyzer. The spectral analysis was stored in the instrument's memory and then output to a graphics plotter. Pre- and trans-sickness segments were plotted on the same graph for each data channel (physiologic parameter). For these graphs, the broken line represents the pre-sickness segment in all cases while the solid line is the trans-sickness period.

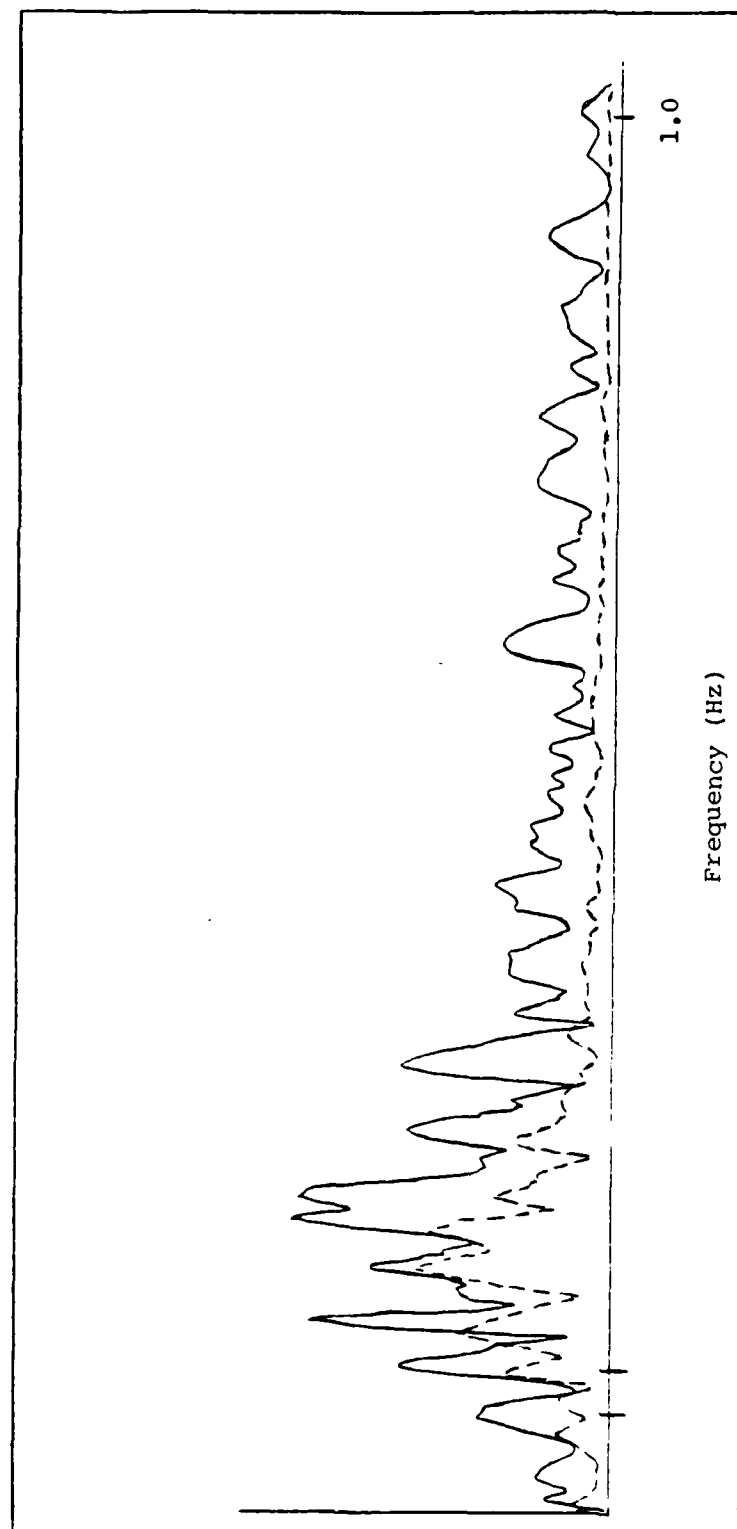


Figure 16. EIG FFT Spectral Analysis

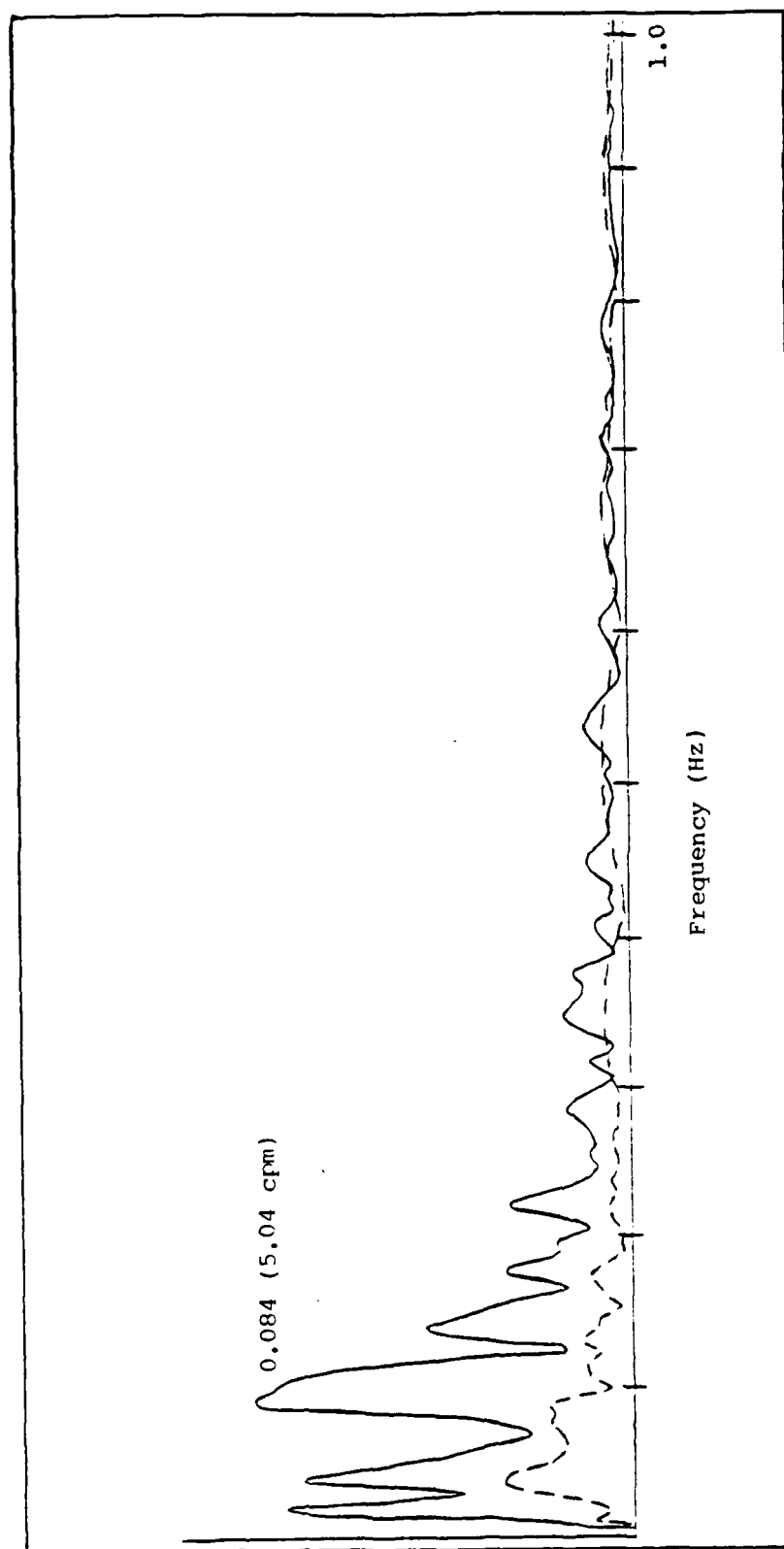


Figure 17. EGG FFT Spectral Analysis

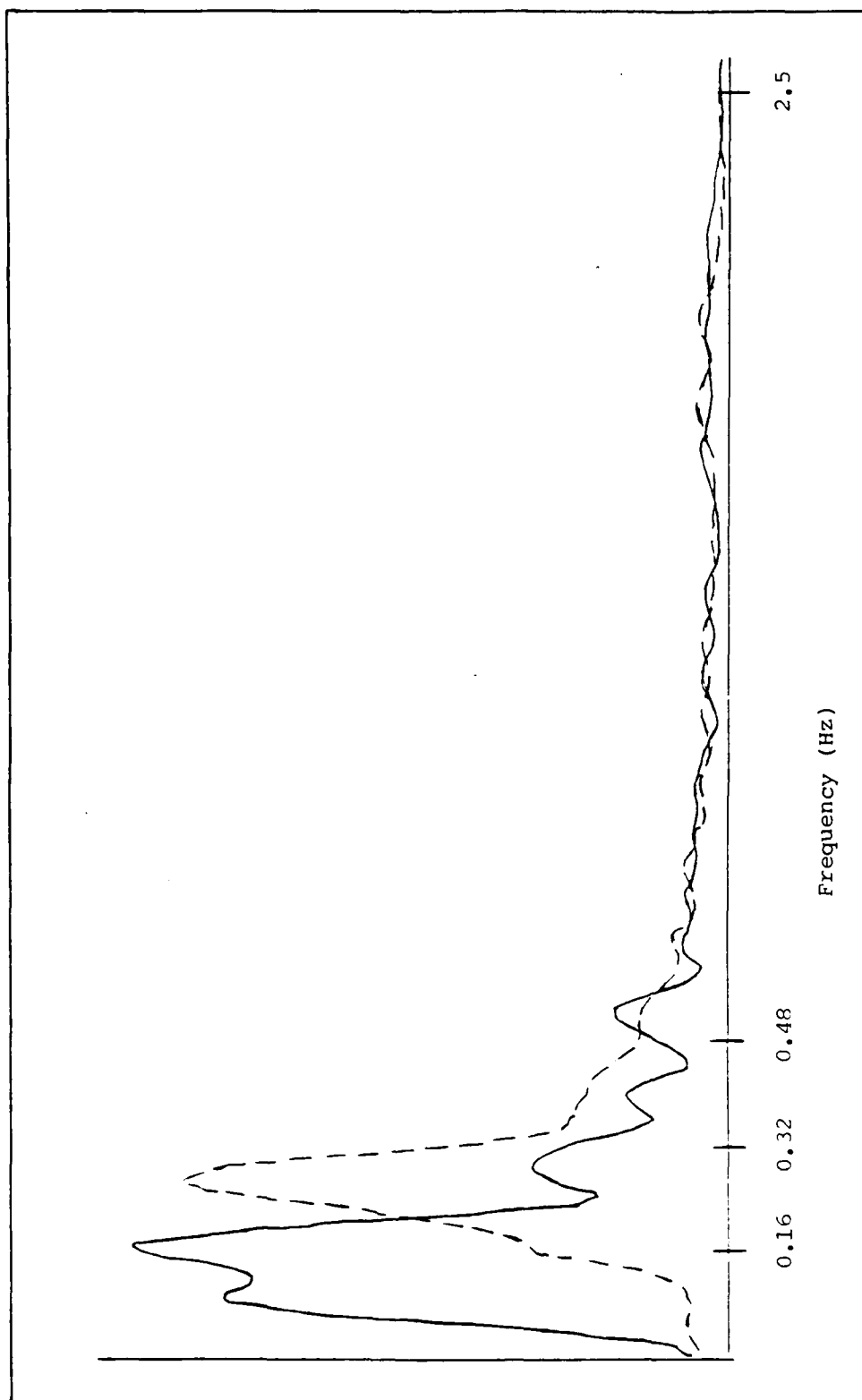


Figure 18. Pneumogram (Thoracic) FFT Spectral Analysis

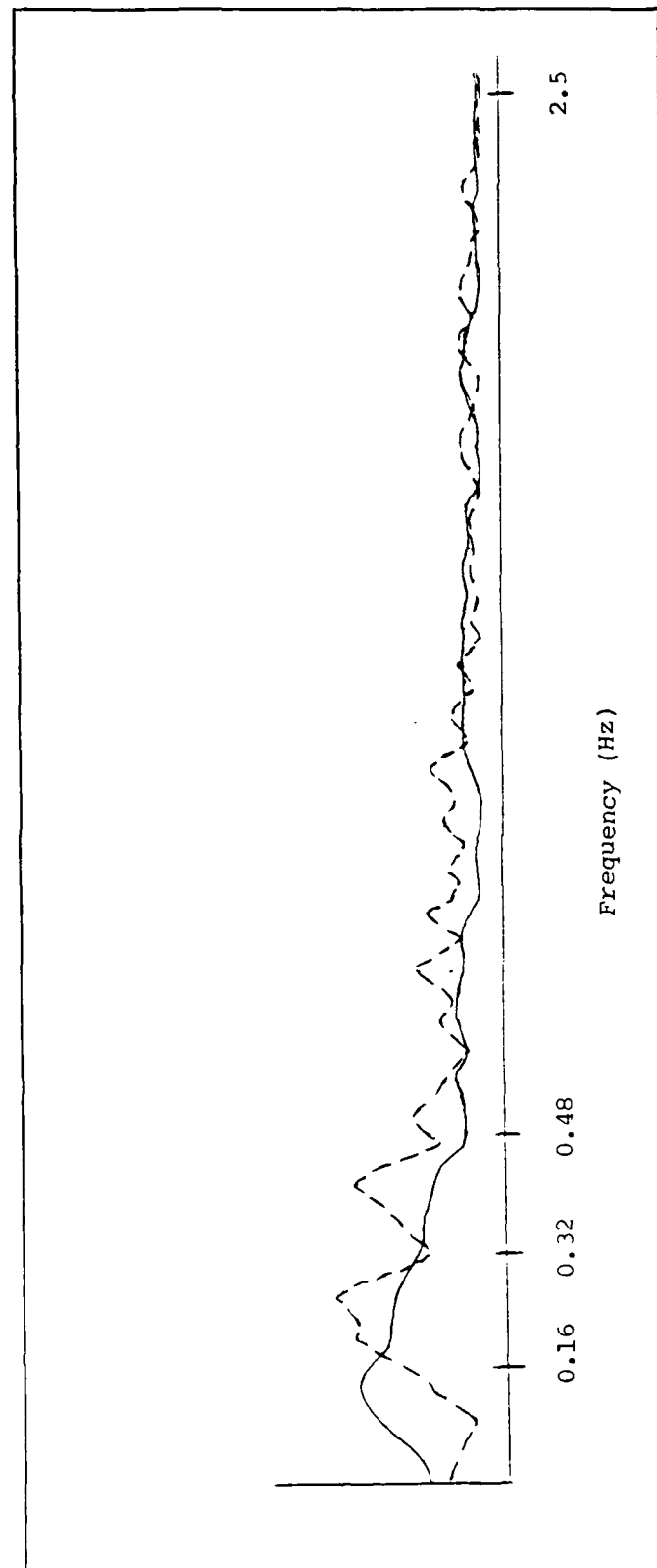


Figure 19. Pneumogram (Abdominal) FFT Spectral Analysis

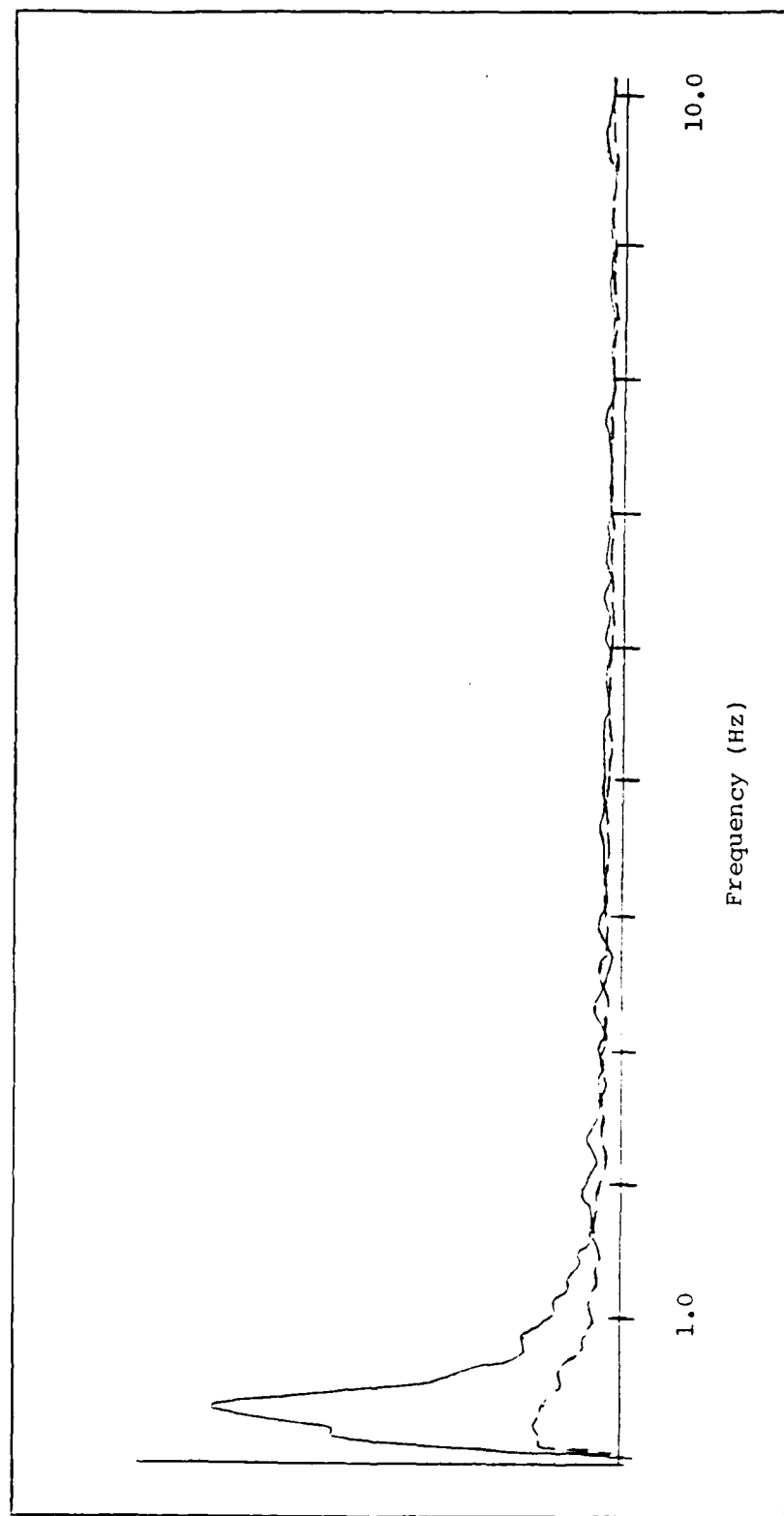


Figure 20. ENG (H) FFT Spectral Analysis

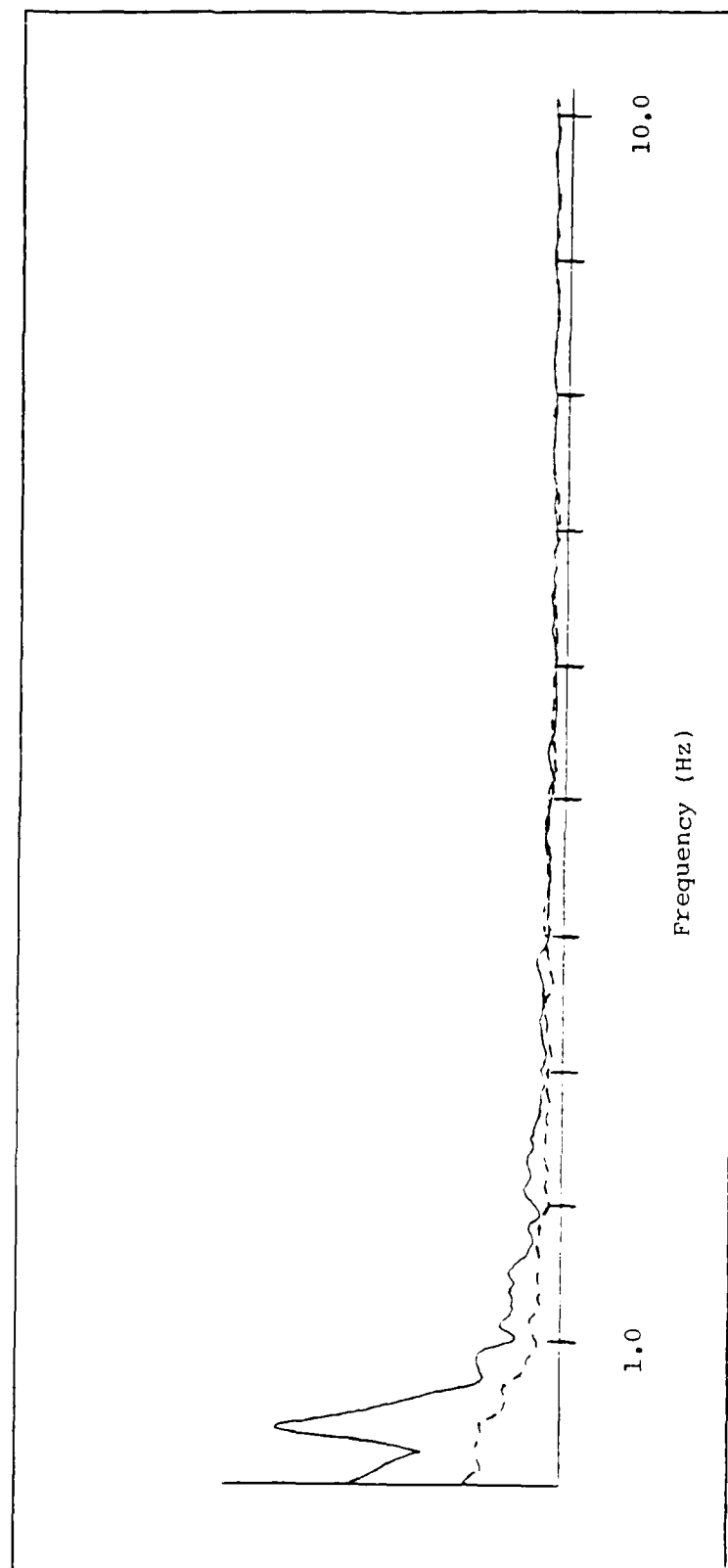


Figure 21. ENG (V) FFT Spectral Analysis



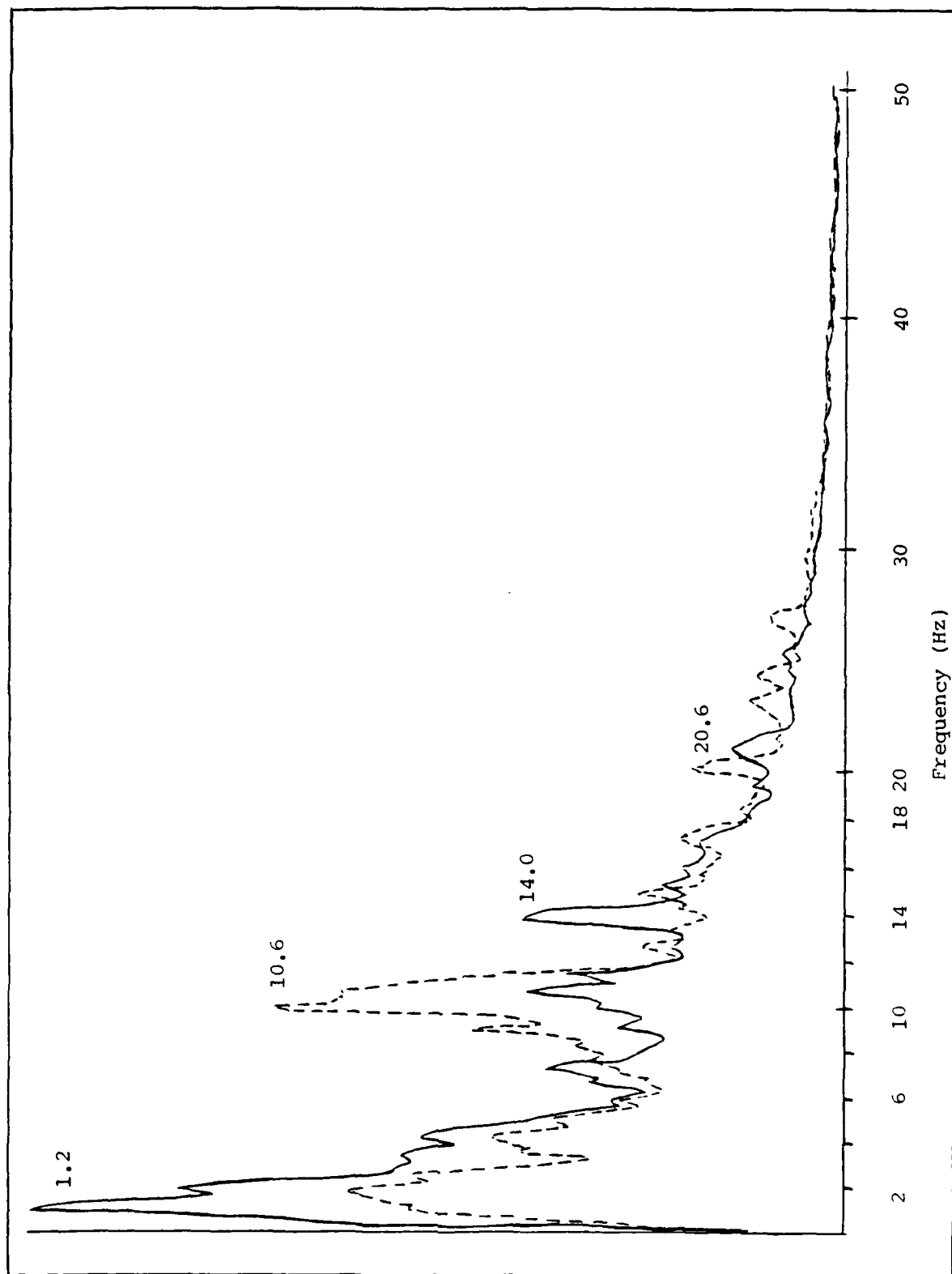


Figure 22. EEG FFT Spectral Analysis

## Appendix B

This appendix contains samples of raw data. These data were obtained from one subject during an experimental run. Figures 23, 24, and 25 show examples of channels 1 to 15 in the pre-sickness phase. Figures 26, 27, and 28 show examples of channels 1 to 15 in the trans-sickness.

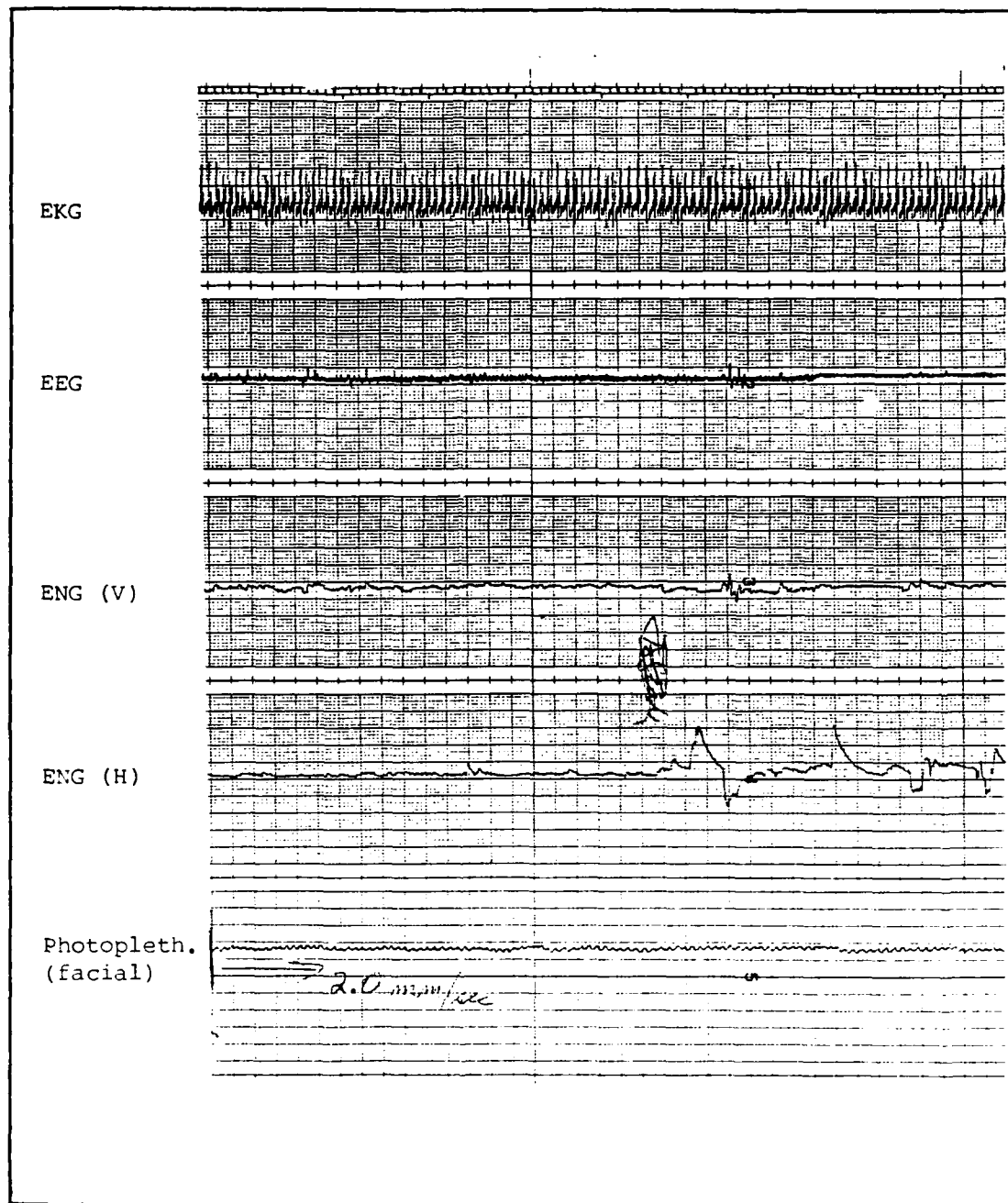


Figure 23. Pre-Sickness

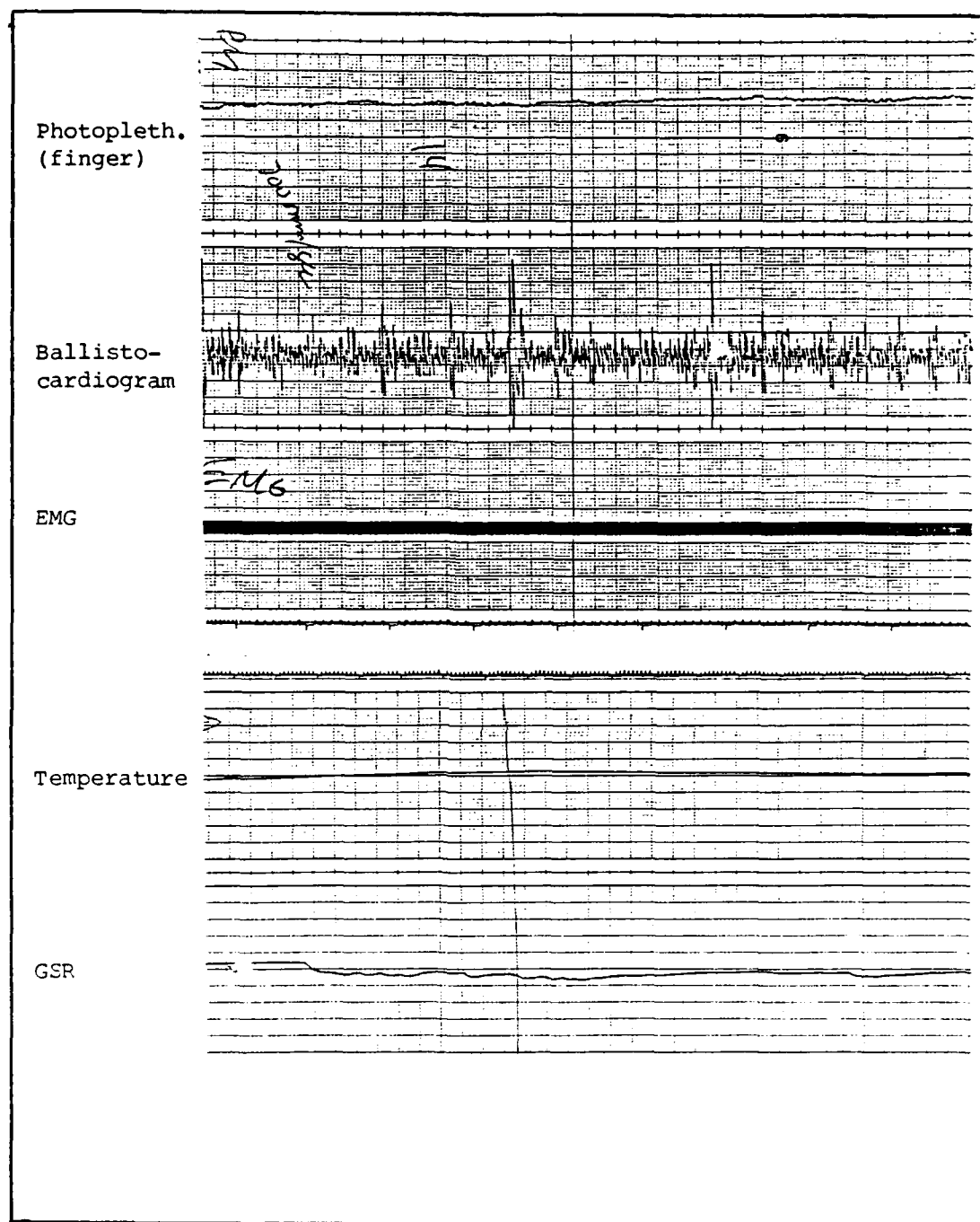
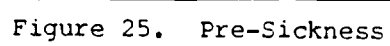


Figure 24. Pre-Sickness



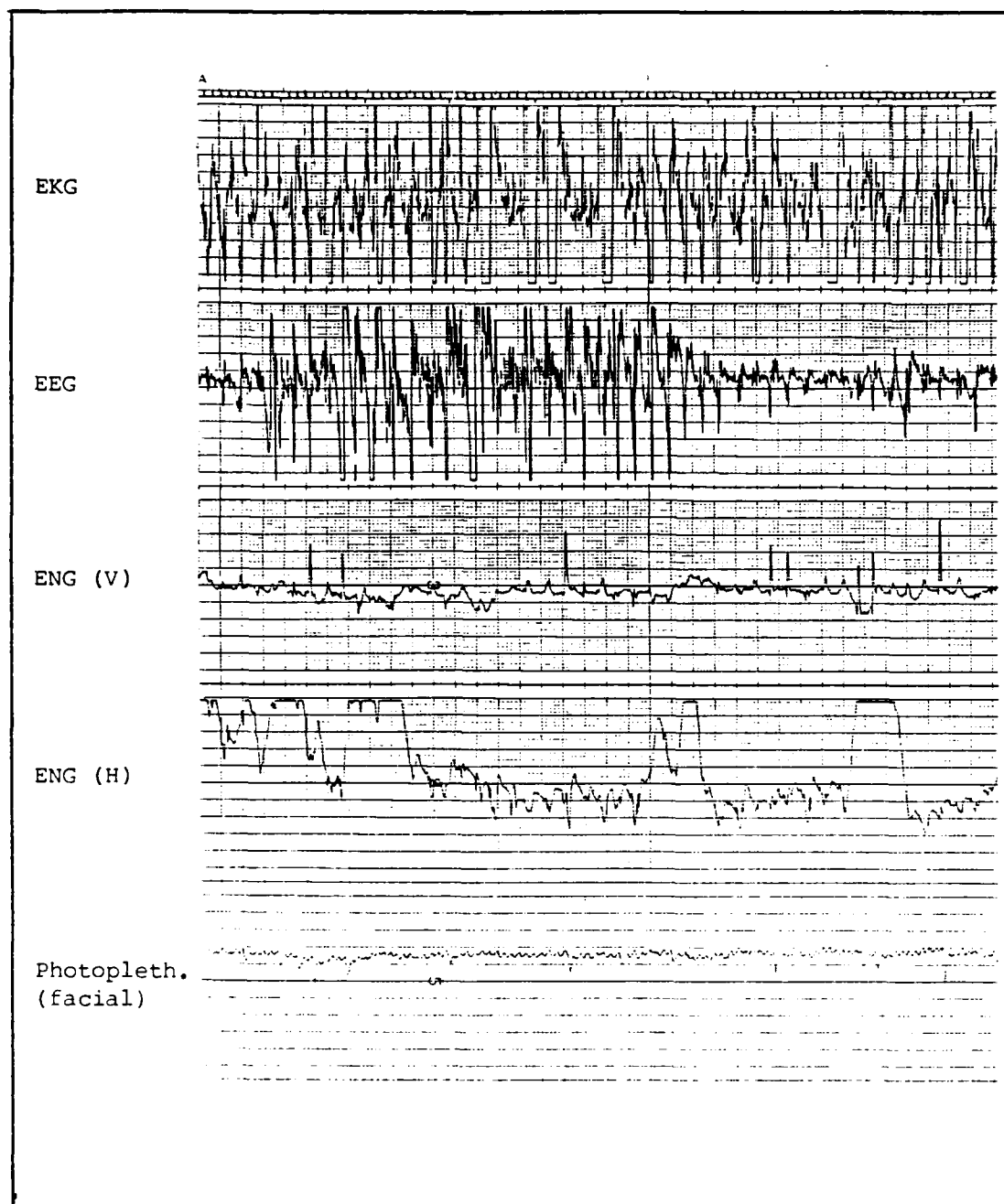


Figure 26. Trans-Sickness

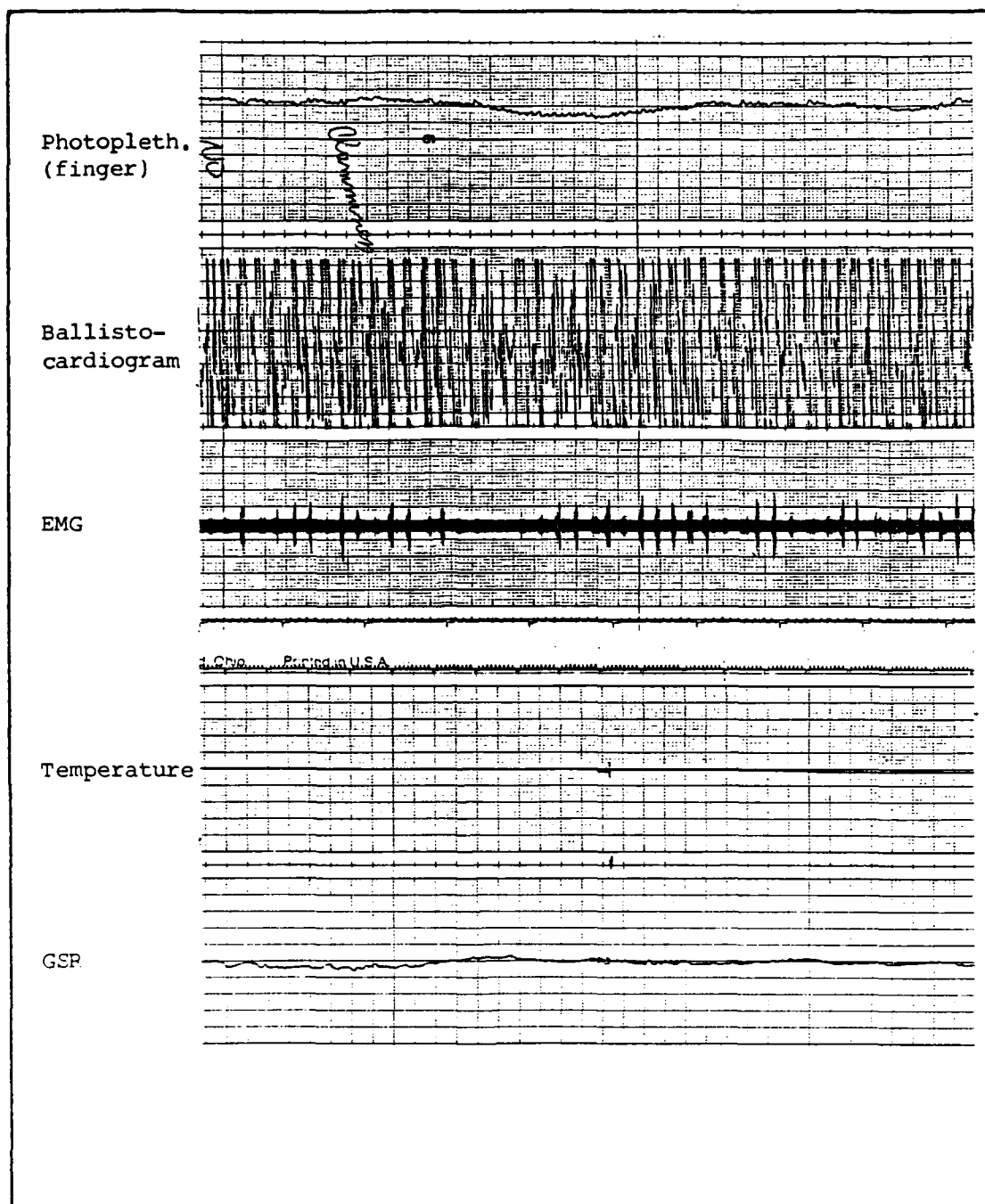


Figure 27. Trans-Sickness

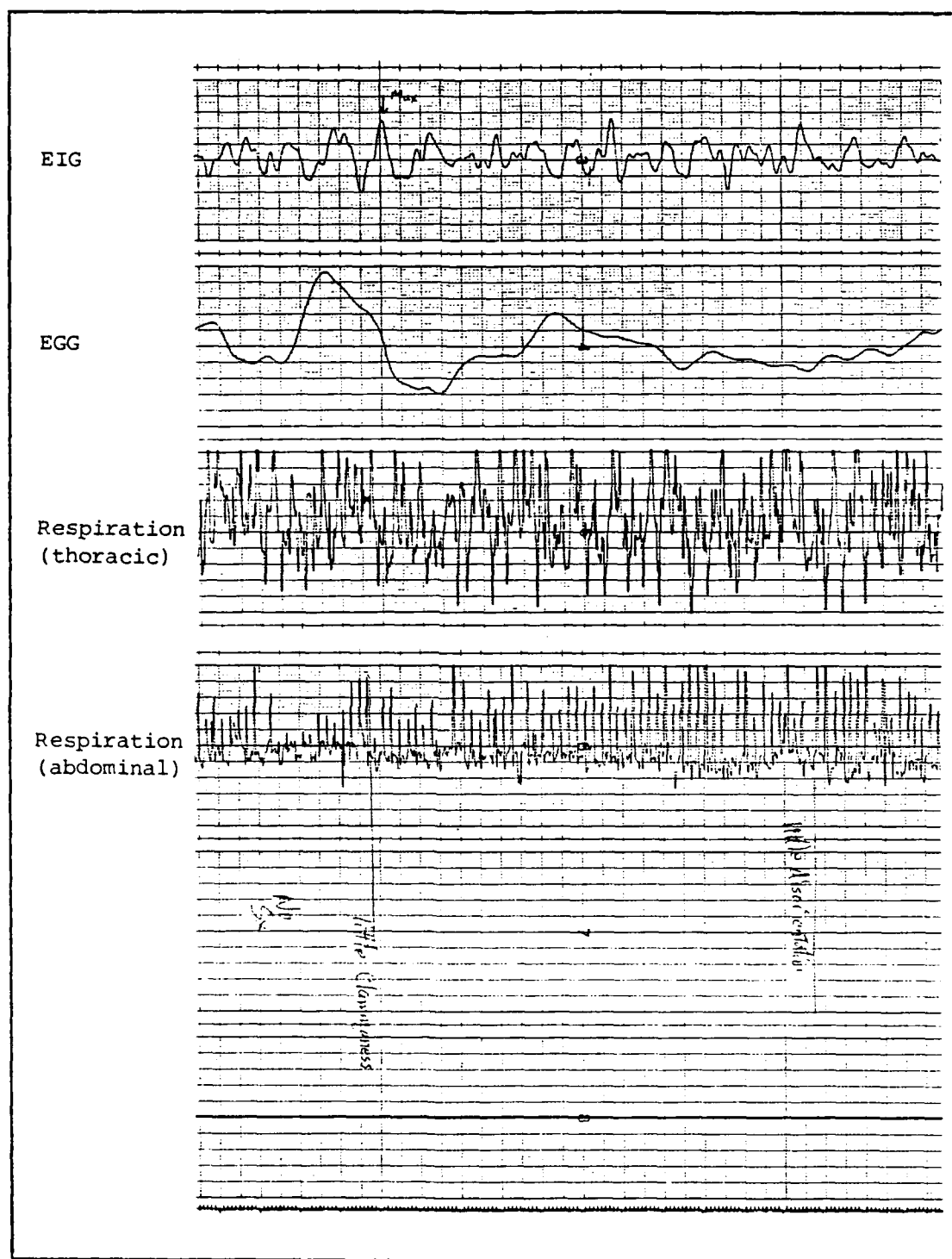


Figure 28. Trans-Sickness



### Appendix C

This appendix contains copies of the following forms and questionnaires used in this study:

Volunteer Briefing Form

Subject Consent Form

Medical History Questionnaire

Motion Sickness Questionnaire

Subject Data Sheet

Record of Computer Collected Data

### VOLUNTEER BRIEFING

You are about to participate in a motion sickness study. But relax. Our purpose is not to make you sick. We anticipate you will feel only the moderate discomfort previous volunteers have.

You will be in constant communication with us. Just follow our directions and everything will run smoothly. The only action you will need to perform is turning the cassette tape recorder on and off when instructed, and to execute the head movements as demonstrated. Otherwise, please keep yourself (especially your hands) as motionless as possible because of the physiological sensors you will be attached to. Also expect that periodically we will operate, without prior warning, the blood pressure cuff.

We will occasionally ask you how you feel. A short description of your overall physical condition ("I feel tired") and/or specific body sensations ("I feel a tingling in my feet") will be fine. We also highly encourage you to report at any time how you feel, or report any specific sensation(s) you may be aware of.

Since you may feel some uncomfortable symptoms, you may be tempted to fight the sensations. PLEASE DO NOT RESIST ANY SYMPTOMS. Doing so may influence the accuracy of our data. Just relax and let whatever happens happen.

The experimental run will end after a certain number of rotations or through our communications with you.

## THE PHYSIOLOGIC CHARACTERIZATION OF MOTION SICKNESS

### SUBJECT CONSENT FORM

If you decide to be a test subject in this test program, then during the time you are used as a test subject you must inform the principal investigator or medical monitor of any change in your medical status. This information will include any medications you have taken and any medical or dental care/treatment you have received. We do not expect you to receive any personal benefit from these exposures. Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. If you give us your permission by signing this document, we plan to disclose the data through official Air Force channels only. In any event, your name will NEVER be identified with the disclosed information without your permission. You are making a decision whether or not to participate. Your signature indicates that you have decided to participate having read the information provided. This form is not valid for female subjects unless the Addendum for Female Consent is attached for review.

I, \_\_\_\_\_ having full capacity to consent, do hereby volunteer to participate in the research study named above. The implications of my voluntary participation; the nature, duration and purpose; the methods and means by which it is to be conducted; and the inconveniences and hazards which may reasonably be expected have been explained to me by \_\_\_\_\_, and set forth on the following page(s) of this Agreement, which I have initialed. I have been given an opportunity to ask questions concerning this research project, and any such questions have been answered to my full and complete satisfaction. I understand that I may at any time during the course of this project revoke my consent and withdraw from the project without prejudice; however, I may be required to undergo certain further examinations, if in the opinion of the attending physician such examinations are necessary for my health or well being. I understand that I may revoke my consent of my participation for any reason. I have been given a complete copy of this agreement to keep.

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

I was present during the explanation referred to above, as well as the volunteer's opportunity for questions, and hereby witness the signature.

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

I have briefed the volunteer and answered questions concerning the research project.

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

<b>REPORT OF MEDICAL HISTORY</b> <small>(THIS INFORMATION IS FOR OFFICIAL AND MEDICALLY-CONFIDENTIAL USE ONLY AND WILL NOT BE RELEASED TO UNAUTHORIZED PERSONS)</small>									
1. LAST NAME—FIRST NAME—MIDDLE NAME					2. SOCIAL SECURITY OR IDENTIFICATION NO.				
3. HOME ADDRESS (No. street or RFD, city or town, State, and ZIP CODE)					4. POSITION (title, grade, component)				
5. PURPOSE OF EXAMINATION			6. DATE OF EXAMINATION		7. EXAMINING FACILITY OR EXAMINER, AND ADDRESS <small>(Include ZIP Code)</small>				
8. STATEMENT OF EXAMINEE'S PRESENT HEALTH AND MEDICATIONS CURRENTLY USED <small>(Follow by description of past history, if complaint exists)</small>									
9. HAVE YOU EVER <small>(Please check each item)</small>					10. DO YOU <small>(Please check each item)</small>				
YES	NO	<small>(Check each item)</small>			YES	NO	<small>(Check each item)</small>		
		Lived with anyone who had tuberculosis					Wear glasses or contact lenses		
		Coughed up blood					Have vision in both eyes		
		Bled excessively after injury or tooth extraction					Wear a hearing aid		
		Attempted suicide					Stutter or stammer habitually		
		Been a sleepwalker					Wear a brace or back support		
11. HAVE YOU EVER HAD OR HAVE YOU NOW <small>(Please check at left of each item)</small>									
YES	NO	DON'T KNOW	<small>(Check each item)</small>		YES	NO	DON'T KNOW	<small>(Check each item)</small>	
			Scarlet fever, erysipelas					Cramps in your legs	
			Rheumatic fever					Frequent indigestion	
			Swollen or painful joints					Stomach, liver, or intestinal trouble	
			Frequent or severe headache					Gall bladder trouble or gallstones	
			Dizziness or fainting spells					Jaundice or hepatitis	
			Eye trouble					Adverse reaction to serum, drug, or medicine	
			Ear, nose, or throat trouble					Broken bones	
			Hearing loss					Tumor, growth, cyst, cancer	
			Chronic or frequent colds					Rupture/hernia	
			Severe tooth or gum trouble					Piles or rectal disease	
			Sinusitis					Frequent or painful urination	
			Hay Fever					Bed wetting since age 12	
			Head injury					Kidney stone or blood in urine	
			Skin diseases					Sugar or albumin in urine	
			Thyroid trouble					VD—Syphilis, gonorrhea, etc.	
			Tuberculosis					Recent gain or loss of weight	
			Asthma					Arthritis, rheumatism, or bursitis	
			Shortness of breath					Bone, joint or other deformity	
			Pain or pressure in chest					Lameness	
			Chronic cough					Loss of finger or toe	
			Palpitation or pounding heart					Painful or "fick" shoulder or elbow	
			Heart trouble					Recurrent back pain	
			High or low blood pressure						
13. WHAT IS YOUR USUAL OCCUPATION?					14. ARE YOU <small>(Check one)</small>				
					<input type="checkbox"/> Right handed <input type="checkbox"/> Left handed				

YES	NO	CHECK EACH ITEM YES OR NO. EVERY ITEM CHECKED YES MUST BE FULLY EXPLAINED IN BLANK SPACE ON RIGHT	
		15. Have you been refused employment or been unable to hold a job or stay in school because of: A. Sensitivity to chemicals, dust, sunlight, etc. B. Inability to perform certain motions. C. Inability to assume certain positions. D. Other medical reasons (If yes, give reasons.)	
		16. Have you ever been treated for a mental condition? (If yes, specify when, where, and give details.)	
		17. Have you ever been denied life insurance? (If yes, state reason and give details.)	
		18. Have you had, or have you been advised to have, any operations? (If yes, describe and give age at which occurred.)	
		19. Have you ever been a patient in any type of hospital? (If yes, specify when, where, why, and name of doctor and complete address of hospital.)	
		20. Have you ever had any illness or injury other than those already noted? (If yes, specify when, where, and give details.)	
		21. Have you consulted or been treated by clinics, physicians, healers, or other practitioners within the past 5 years for other than minor illnesses? (If yes, give complete address of doctor, hospital, clinic, and details.)	
		22. Have you ever been rejected for military service because of physical, mental, or other reasons? (If yes, give date and reason for rejection.)	
		23. Have you ever been discharged from military service because of physical, mental, or other reasons? (If yes, give date, reason, and type of discharge: whether honorable, other than honorable, for unfitness or unsuitability.)	
		24. Have you ever received, is there pending, or have you applied for pension or compensation for existing disability? (If yes, specify what kind, granted by whom, and what amount, when, why.)	
<p>I certify that I have reviewed the foregoing information supplied by me and that it is true and complete to the best of my knowledge. I authorize any of the doctors, hospitals, or clinics mentioned above to furnish the Government a complete transcript of my medical record for purposes of processing my application for this employment or service.</p>			
TYPED OR PRINTED NAME OF EXAMINEE		SIGNATURE	
<p>NOTE. HAND TO THE DOCTOR OR NURSE, OR IF MAILED MARK ENVELOPE "TO BE OPENED BY MEDICAL OFFICER ONLY." 25. Physician's summary and elaboration of all pertinent data (Physician shall comment on all positive answers in items 9 through 24. Physician may develop by interview any additional medical history he deems important, and record any significant findings here.)</p>			
TYPED OR PRINTED NAME OF PHYSICIAN OR EXAMINER		DATE	SIGNATURE
			NUMBER OF ATTACHED SHEETS

REVERSE OF STANDARD FORM 93

A.F.I.T. Motion Sickness Laboratory

Motion Sickness Questionnaire

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Rank: \_\_\_\_\_ Age: \_\_\_\_\_ Sex: \_\_\_\_\_

Address: \_\_\_\_\_

Weight: \_\_\_\_\_ Height: \_\_\_\_\_

Introduction:

This questionnaire is designed to find out:

- (a) how susceptible to motion sickness you are, and
- (b) what types of motion are most provocative to you

Section A is concerned with childhood (prior to age 12) experiences of motion sickness.

Section B is concerned with your experiences of motion sickness over the past 10 years.

Section C is concerned with your present susceptibility to motion sickness.

Please read and follow carefully the instructions for each question. The answers to these questions are important in evaluating your performance in this experiment. This information will be kept in the strictest confidence. Thank you for your help.

# Section A

All the questions in this section refer to your childhood experiences of motion sickness (if any), where childhood is defined as the period prior to 12 years of age. It is quite possible that you will have difficulty in recalling childhood motion sickness; nevertheless, please try to answer the questions to the best of your ability.

	C A R S S E S	T R A I N S	A I R P L A N E S	B O A T S	S H I P S	P E R I O D I C G R O U N D	P A R K E M E N T S
<p>(1) Indicate approximately how often you travelled on each type (before age 12) by using the following:</p> <p>0 = no experience            1 = less than 5 trips            2 = between 5 and 10            3 = more than 10</p>							
<p>Considering only those types of transport that you have experience with, answer the two questions below. (Use the following letters to indicate your response):</p> <p>N =Never; R =Rarely; S =Sometimes; F =Frequently; A =Always</p>							
(2) How often did you feel sick while travelling, (i.e. queasy or nauseated)?							
(3) How often were you actually sick, (i.e. vomiting)?							



## Section B

This section is concerned solely with your experiences of motion sickness over approximately the last 10 years.

	C A R S	B U S E S	T R A I N S	A I R P L A N E	B O A T S	S H I P S	P E L A Y I P R O G R E S S	A P P A R E N C E S
<p>(1) Indicate approximately how often you travelled on each type (over the last 10 years) by using the following:</p> <p>0 = no experience            1 = less than 5 trips            2 = between 5 and 10            3 = more than 10</p>								
<p>Considering only those types of transport that you marked above, answer the two questions below. (Use the following letters to indicate your response):</p> <p>N =Never; R =Rarely; S =Sometimes; F =Frequently; A =Always</p>								
(2) How often did you feel sick while travelling, (i.e. queasy or nauseated)?								
(3) How often were you actually sick, (i.e. vomiting)?								

Section C

This section is concerned with your present susceptibility to motion sickness. If a question does not apply to you, enter "None" or "NA".

- (1) What is your current flying status? (Pilot, Navigator, UPT/UNT, etc.) \_\_\_\_\_
- (2) What operational or fully qualified flying experience have you had? (Plane, Hours, Crew position, Command) \_\_\_\_\_
- (3) I (have; have not) been treated for motion sickness. My treatment consisted of \_\_\_\_\_  
\_\_\_\_\_ for \_\_\_\_\_ months, at \_\_\_\_\_ by \_\_\_\_\_, which (did; did not) help. Treatment did not help because \_\_\_\_\_
- (4) I currently consider myself:
- (a) Mildly
  - (b) Moderately
  - (c) Severely
  - (d) Not at all . . . susceptible to motion sickness.
- (5) When the opportunity arises, I:
- (a) Almost never
  - (b) Sometimes
  - (c) Almost always . . . participate in carnival or midway rides.

(6) I would describe my current experiences with motion sickness as:

- (a) Totally disabling
- (b) Occasionally disabling
- (c) Debilitating but not disabling
- (d) Only bothersome
- (e) Not affected.

(7) When I have been airsick on a flight, I:

- (a) Almost always
- (b) Sometimes
- (c) Almost never . . . have difficulty deplaning.
- (d) No airsickness experienced.

(8) Other members of my family are susceptible to motion sickness

- (a) Don't know
- (b) No
- (c) Yes (elaborate) \_\_\_\_\_.

(9) The following symptoms usually accompany my experience of motion sickness: (circle all that apply)

Nausea	Dizziness
Vomiting	Disorientation
Sweatiness	Desire to be left alone
Gassiness	Yawning
Coldness	Difficult concentration
Churning stomach	Tingling hands/feet
Reluctance for physical or mental work	Objects/sounds seem distant
Headache	Chest pains
Fatigue or drowsiness	Distractibility
Faintness	Thick headedness
Blurred/tunnel vision	Spaced out
Other (elaborate) _____.	

(10) I have found the following situations and their accompanying body motion sensations to be pleasurable for the most part: (Indicate any not experienced by marking "N/A".)

<input type="checkbox"/> Fast elevator rides	<input type="checkbox"/> Gymnastics
<input type="checkbox"/> Escalator rides	<input type="checkbox"/> Inverted flight
<input type="checkbox"/> Dancing	<input type="checkbox"/> Mountain driving
<input type="checkbox"/> Inflight positive G's	<input type="checkbox"/> Hammocks
<input type="checkbox"/> Inflight negative G's	<input type="checkbox"/> Tipsy from drinking
<input type="checkbox"/> Skiing (water/snow)	<input type="checkbox"/> Jogging
<input type="checkbox"/> Train/subway rides	<input type="checkbox"/> Skating
<input type="checkbox"/> Swings	<input type="checkbox"/> Motorcycle riding
<input type="checkbox"/> Merry-go-rounds	<input type="checkbox"/> Glider/small planes
<input type="checkbox"/> Roller coasters	<input type="checkbox"/> Boating
<input type="checkbox"/> Other midway rides	<input type="checkbox"/> Low level flight
<input type="checkbox"/> Stationary spinning	<input type="checkbox"/> Ships
<input type="checkbox"/> Other (elaborate) _____	

(11) Have you ever washed out, or otherwise been eliminated from a flying-training program? ☐ No

☐ Yes (elaborate) \_\_\_\_\_

(12) Are you currently taking any medications (including aspirin and antihistamines)? ☐ No ☐ Yes

If so, please specify \_\_\_\_\_

How long? \_\_\_\_\_

(13) Have you had any alcohol in the past 24 hrs?

☐ No ☐ Yes

(14) How long ago was your last meal? \_\_\_\_\_ hrs

(15) Have you had any unusual motion stimuli in the past 24 hrs (aircraft rides, carnival rides, etc.)?

☐ No ☐ Yes If so, please specify \_\_\_\_\_

\_\_\_\_\_

(16) Have you had any vision problems recently (general worsening, change in prescription of corrective lenses, etc.)? ☐ No ☐ Yes If so, please specify \_\_\_\_\_

(17) Have you had any stomach upsets in the past 24 hrs? ☐ No ☐ Yes

(18) What is your current assessment of your health? ☐ Excellent ☐ Good ☐ Fair ☐ Poor

## SUBJECT DATA SHEET

NAME: \_\_\_\_\_

DATE: \_\_\_\_\_

### CHECKLIST

Questionnaire Complete \_\_\_\_\_

Briefed \_\_\_\_\_

Waiver Signed \_\_\_\_\_

Medical Examination \_\_\_\_\_

### ENVIRONMENTAL CONDITIONS

Ambient Air Temperature \_\_\_\_\_

Relative Humidity \_\_\_\_\_

### RUN DATA

Rotation Start Time (HR:MIN:SEC) \_\_\_\_\_

Rotation Stop Time (HR:MIN:SEC) \_\_\_\_\_

Revolutions/Minute \_\_\_\_\_

Total Rotation Time \_\_\_\_\_

No. of Rotations \_\_\_\_\_

Tape recorder Stop Time \_\_\_\_\_

No. of Head Movements \_\_\_\_\_

### COMMENTS

AFIT MOTION SICKNESS LABORATORY  
RECORD OF COMPUTER COLLECTED DATA

NAME: \_\_\_\_\_ DATE: \_\_\_\_\_

Channel Order File: \_\_\_\_\_

Session File: \_\_\_\_\_

Data File (Binary): \_\_\_\_\_ Size (Bytes): \_\_\_\_\_

Storage Medium: \_\_\_\_\_

Channels Extracted:

Channel

Storage Medium

## Appendix D

### MASSCOMP MC500

Problems Encountered in this Study. The MASSCOMP MC500 computer system essentially did not function for the duration of this thesis effort. However, this fact and the actual extent of the problem were not known until late in the thesis program, otherwise another computer or an alternative approach would have been used.

It was known at the beginning of this effort that there were problems with collecting data on the computer's small hard disk (27 Megabyte). Preliminary test runs done in the spring of 1984 indicated that the MC500 would only collect one to two minutes of data before it stopped functioning. This was assumed to be a software fault and significant emphasis early in this thesis effort was placed on understanding the software and attempting to find and correct the fault. In depth study of the software code failed to reveal the fault although other minor errors were found and corrected. Additionally, more documentation comments were inserted into the code to facilitate future analysis. System testing and analysis were then begun to further isolate the fault when hot summer weather arrived and with it more problems for the computer system.

The following background facts must be considered. The MASSCOMP computer and HATS chair were both located in building 470 on Wright-Patterson AFB at the beginning of this



thesis effort. This building is a former thermonuclear reactor which was deactivated in 1971. Although still used for research lab and shop support space, the building is essentially in caretaker status and is not eligible for major modifications or repairs. Early in the summer of 1985 the air conditioning system failed. This 30 year old system had been repaired many times but as quickly as one part was fixed another would break. Also, although the air conditioner, when operational, could handle the temperature, it required the base steam supply to control the humidity. The base steam system was shut down for steam line maintenance and repairs. These problems led to frequent environmental conditions within the building of 90 degree Fahrenheit temperature readings along with 90% humidity. The MC500 computer could not operate under these conditions. The computer overheated, burned out the disk controller board, caused the 166 Megabyte large hard disk to fail, probably contributed to errors on the 27 Megabyte disk, and possibly accounted for erratic performance of the tape drive. In short, the entire computer system failed.

In October, 1985, the MC500 system was moved to building 640 (AFIT School of Engineering) for repair and check-out. As of 1 October 1985, a hardware maintenance agreement was in effect with the Massachusetts Computer Corporation (MASSCOMP). Under this contract, repair personnel were called in and by 15 November the system was fully

operational. This was, however, too late to assist the current thesis effort.

Also beginning on 1 October, AFIT had a Software Subscription Service agreement with MASSCOMP to cover all new software updates, documentation, and programming support. As mentioned in Chapter V, the MC500 system at AFIT had software installed that was incompatible with the hardware. As of this writing, this problem has been rectified and new documentation is being shipped from MASSCOMP. It is hoped that the repaired hardware and updated (correct) software will allow computer collection and analysis of biophysical data.

## A.F.I.T. Motion Sickness Laboratory

### Data Acquisition and Display System (DAADS)

#### Users Guide

1. If the computer is on, proceed to step 2, if not, refer to: `USERS_GUIDE` for MASSCOMP MC-500 WITH UNIX for power up instructions.
2. Log on to the computer.
3. Change directory (`cd`) with the following command:

```
mc500 #1  cd /usr/jarvis/daads <CR>
```

The "mc500 #1" in the line above is the MASSCOMP system prompt, and the "<CR>" notation means carriage return.

4. To ensure you are in the correct directory, do a 'print working directory' command by typing:

```
mc500 #2  pwd <CR>
```

The computer should respond with:

```
/usr/jarvis/daads
```

If you get some other response, go to the root directory by typing:

```
mc500 #3  cd / <CR>
```

and return to step 3.

5. To see the contents of the directory, type:

```
mc500 #4  ls -al <CR>
```

This means list (`ls`) all files and subdirectories (`-al`) and list them with the long (`l`) option so that more than just the filenames is given.

Besides the DAADS program itself, at least one other file must be present. It is the channel order file that prescribes the order for the displayed channels, any secondary data reduction to be performed, and the channel labels to be applied to the displayed windows. This file is fully described in the Fitzpatrick, Rogers, and Williams thesis (FRW:G-9). If a channel order file is not in the directory listing, or it requires alteration, proceed to step 6, if not, go to step 7.

6. To make a new channel order file, or to change an existing one, do the following. While in the /usr/ljvris/daads directory, enter the "vi" text editor by typing:

```
mc500 #5 vi chanelorder <CR>
```

This command enables the visual (vi) full page text editor and opens a file called "chanelorder". Any other file name could be used as long as there are no blank spaces in the name. For a complete description of the vi text editor, see *Introducing the Unix System* by McGilton and Morgan (MM:265).

The command above will clear the screen and place the cursor in the upper left corner. Begin typing the file exactly as described in Appendix B of the Fitzpatrick, Rogers, and Williams thesis. The following is a guide:

```
00 0010 EKG
01 0010 Temp
02 0005 ENG (H)
03 0005 ENG (U)
04 0020 GSR
" " "
" " "
```

(up to 16 channels if needed)

The first column is the channel number and must begin with 00 and follow sequentially. The second column is a secondary data reduction factor and has the effect of selecting the 1/n<sup>th</sup> data points for display, thus lengthening the window display time for that channel. The third column is the display window label and can be any set of characters (including blanks) up to twenty long.

When finished, type a colon (:). The colon and cursor will be placed at the lower left of the screen. Then type:

```
qwr <CR>
```

This tells the editor to write (wr) (store) the file and to quit (q) the editor. The file name "chanelorder" (or the one you choose) will be the one to give when the DAADS program asks for the channel order file.

7. Another file is used by the DAADS program to control the set-up or configuration for the data collection session. It is appropriately called the session set-up file. It may be established in advance and used repeatedly for different sessions, or it can be written in an interactive manner as prompted by the DAADS program each time DAADS is run. To write the file in advance, enter the vi editor as described above by typing:

```
mc500 #6 vi setup file <CR>
```

Then input the following information:

```
14          (the number of channels to collect)
08          (the number of channels to display)
02          (collection mode: 01=parallel 02=analog)
Tom_Jones   (session file, to identify the session)
Jones_bin   (output file for collected binary data)
chanelorder (the channel order file as given above)
```

This information is stored in the file "setup\_file" and this is the file name to give when prompted under the "Use standard set-up file." option in the DAADS program "Data Collection and Display." module. It also must be given in the "Replay a previous collection." module.

8. To get a handcopy printout of the above files (chanelorder or setup\_file), ensure the printer is on, has paper properly positioned (paper perforation falls just below the rollers on the platten), and the "on" and "sel" buttons are both lit. Then type:

```
mc500 #7 lpr chanelorder
mc500 #8 lpr setup_file
```

9. To actually run the DAADS program for a data collection, replay a session, or extract a channel option, simply type the file name:

```
mc500 #9 DAADS
```

The program is interactive and menu driven. Input the appropriate response when prompted.

10. To begin the actual data storage, type "W" when prompted. Know how much file space is available and do not exceed it, otherwise the program will crash and data could be lost. If a second terminal is available (besides the graphics display terminal) file space can be monitored by typing:

```
mc500 #10 df
```

This asks for the "disk free" space on the hard disk. The command can be repeated any number of times by hitting "!!" after the prompt. It is recommended that "df" be checked frequently as the program is running.

11. To stop the data storage, type "W" again or type "Q" to quit the data collection session and exit from the DAADS program.
12. The following source files are necessary for compiling a DAADS program:

```
elldtdata.c
collect.c
daadsmnu.c
extractchan.c
globals.h
initchorder.c
initda.c
initonaphics.c
replay.c
round.c
```

The DAADS program may be compiled conveniently by using the preset command in the file called "compile". Simply type:

```
mc500 #11 compile
```

13. The following files are necessary to run the DAADS program:

```
DAADS
chanelorder
setup
```

The "chanelorder" and "setup" files are user defined so the names may be different, but they still must be present for the program to run. The "setup" file may be omitted if the user decides to create it interactively in the DAADS program.

# APPENDIX D DAADS PROGRAM SOURCE FILES DIRECTORY

	Module	Page
A0	daadsmnu .....	159
A1	presentmenu .....	162
A2	processmainrequest .....	163
	A21 clldtdata .....	165
	A211 presentdacqmn .....	167
	A212 processdacqrequest .....	168
	A2121 read_setup .....	171
	A2122 interactive_setup .....	179
	A2123 initgraphics .....	187
	A21231 initchorder .....	194
	A21232 place_windows .....	196
	A21233 create_segment .....	197
	A2124 initda .....	198
	A2125 collectdata .....	203
	A21251 para_collect .....	208
	A21252 analog_collect .....	211
A22	extractchan .....	214
	A221 presentextm .....	217
	A222 doextraction .....	218
A23	replay .....	225
	A231 presentreplaym .....	227
	A232 doneplay .....	228
	A2321 para_display .....	231
	A2322 analog_display .....	233
A24	data_analysis .....	235
	Miscellaneous Files	
	globals.h .....	236
	chanorder .....	238
	set-up .....	239
	round.c .....	240

```

/*****
*
*   NOTE:
*
*   The DAADS program source files in this directory
*   are not ones that can be compiled for an executable
*   DAADS program. They have been reformatted to fit
*   the margin constraints of an AFIT thesis. Although
*   they are identical in content to the original source
*   files, some commands (ie. #include, and #define) will
*   not work in anything but the first column position.
*   These files are for cosmetic purposes only.
*
*                               NRJ  3 Oct 85
*
*****/

```



```

/*****
*
*   DATE:
*   VERSION: 1.2
*   TITLE: Daads main menu
*   FILENAME: daadsmnu.c
*   OWNER: BDAS system manager
*   SOFTWARE SYSTEM: MASSCOMP
*   OPERATING SYSTEM: Unix version III
*   USE: Driver file, compile with clctdata.c,
*   extractchan.c, replay.c and dataanalysis.c, all
*   should be included files along with stdio.h.
*   CONTENTS:  A1 presentmenu - presents the main menu
*               A2 proccssmainrequest - from user
*               response, branches to DAADS function
*               selected.
*   FUNCTION:  Contains the DAADS main driver programs.
*
*****/

#include <stdio.h>
#include <math.h> /* system math file for "round" procedure
                  in initda.c */

/* defines for menu */

#define EXIT 5
#define dataacq "1) Data Collection and Display.\n"
#define extrackmnu "2) Extract a channel from a file.\n"
#define replaymnu "3) Replay a previous collection.\n"
#define dataanalysis "4) Perform data analysis.\n"
#define EXITMAIN "5) Exit DAADS program.\n"

/* Global defines used by all menus */

#define MEXIT 5
#define CR "\n"
#define NOTREADY "This option is not available at this
                 time\n"
#define TRYANOTHER "Please try another option\n"
#define TRYAGAIN "Incorrect response, please try again\n"
#define HITRETURN "Please hit return when ready\n"
#define afit "Air Force Institute of Technology\n"
#define sysname "Data Acquisition and Display System\n"
#define mainmnu "Main Menu Module\n"
#define dacqmnu "Data Acquisition and Display Module\n"
#define extrkmnu "Extract Single Channel Module\n"
#define replymnu "Replay Module\n"
#define analysisda "Perform Data Analysis Module\n"
#define SNOOZE 2

```

```

/* cursor control character for h19 */

#define CLEARSC      "\033E\n"

/* defines used by initgraphics and replay modules */

#define MAXWINDOWS    12
#define DISPBUFFSIZE  110
#define NDISPBUFFS     MAXWINDOWS
int display_buff[NDISPBUFFS][DISPBUFFSIZE] = {0};
#include "cllctdata.c"
#include "extractchan.c"
#include "replay.c"

/**include "datanalysis.c"*/

/* The statement above is in comment quotes because this
   option is not available at this time. At a later date,
   when the data analysis software is written, the comment
   markers can be removed and the program recompiled to
   include that option. */

```

```

/*****
*
*   DATE:
*   VERSION: 1.2
*   NAME: main
*   MODULE NUMBER: A0
*   FUNCTION: Starts the DAADS system by calling module
*             to present a main menu and process the
*             user responses.
*   INPUTS: None
*   OUTPUTS: answer
*   GLOBAL VARIABLES USED: None
*   GLOBAL VARIABLES CHANGED: None
*   GLOBAL TABLES USED: None
*   GLOBAL TABLES CHANGED: None
*   FILES READ: None
*   FILES WRITTEN: None
*   MODULES CALLED: A1 presentmainmnu,
*                  A2 processmainrequest
*   CALLING MODULES: User
*   AUTHOR: Capt Douglas G. Fitzpatrick
*   HISTORY: None
*
*****/

```

```
main()
```

```
{
```

```
    char answer[2];
```

```
    char temp;
```

```
    do
```

```
    {
```

```
        printf(CLEARSC);
```

```
        sleep(2);
```

```
        presentmenu();
```

```
        scanf("%s",answer);
```

```
        processmainrequest(answer);
```

```
    }
```

```
    while (answer[0] !=MEXIT);
```

```
} /* end main */
```

```

/*****
*
*   DATE:
*   VERSION: 1.2
*   NAME: presentmenu
*   MODULE NUMBER: A1
*   FUNCTION: Presents main menu on the screen,
*             then asks the user to select a response.
*   INPUTS: None
*   OUTPUTS: None
*   GLOBAL VARIABLES USED: afit, sysname, mainmnu,
*                         dataacq, extrackmnu,
*                         replaymnu, dataanalysis, CR
*   GLOBAL VARIABLES CHANGED: None
*   GLOBAL TABLES USED: None
*   GLOBAL TABLES CHANGED: None
*   FILES READ: None
*   FILES WRITTEN: None
*   MODULES CALLED: None
*   CALLING MODULES: A0 daadsmnu
*   AUTHOR: Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/
presentmenu()
{
printf("                ");
printf(afit);
printf("                ");
printf(sysname);
printf("                ");
printf(mainmnu);
printf(CR);
printf(CR);
printf("Please examine the menu below and indicate the
      type of operation\n");
printf("you wish to perform. \n");
printf(CR);
printf("Main Menu:  \n");
printf(CR);
printf(dataacq);
printf(extrackmnu);
printf(replaymnu);
printf(dataanalysis);
printf(EXITMAIN);
printf(CR);
printf(CR);
printf("Please indicate choice by typing in corresponding
      number above: ");
} /* end presentmenu */

```

```

/*****
*
*   DATE:
*   VERSION: 1.2
*   NAME: processmainrequest
*   MODULE NUMBER: A2
*   FUNCTION: Determines from the user response to
*             'answer' the DAADS function to branch to.*
*             If 'answer' is valid a simple transfer of *
*             control occurs. If not, a return to A1 *
*             occurs. This happens until a valid *
*             response is given by the user.
*
*   INPUTS: answer
*   OUTPUTS: None
*   GLOBAL VARIABLES USED: TRYAGAIN, SNOOZE
*   GLOBAL VARIABLES CHANGED: None
*   GLOBAL TABLES USED: None
*   GLOBAL TABLES CHANGED: None
*   FILES READ: None
*   FILES WRITTEN: None
*   MODULES CALLED: A21 cllctdata, A22 extrnactchan,
*                  A23 replay, A24 data_analysis
*   CALLING MODULES: A0 daadsmnu
*   AUTHOR: Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

```

```
processmainrequest(r)
```

```

    char *r;

    {
    int c;

    c = r[0];

    switch(c)
    {
        case '1': {
            cllctdata();
            break;
        }

        case '2': {
            extractchan();
            break;
        }
    }
    }

```

```

        case '3': {
            replay();
            break;
        }

        case '4': {
            data_analysis();
            break;
        }

        case EXIT: {
            printf("Goodbye\n");
            break;
        }

        default: {
            printf(TRYAGAIN);
            sleep(SNDOZE);
            break;
        }
    }

} /* end processmainrequest */

data_analysis()
{
    printf(NOTREADY);
    printf(CR);
    printf(TRYANOTHER);
    printf(CR);
    printf(CR);
}

/*****          END OF FILE          *****/

```

```

/*****
*
*   DATE:      4 October 1985
*   VERSION:   1.2
*   TITLE:    Collect and store data
*   FILENAME:  cl1ctdata.c
*   OWNER:    BDAS system manager
*   SOFTWARE SYSTEM:  MASSCOMP
*   OPERATING SYSTEM:  Unix version III
*   LANGUAGE:  C
*   USE:    included with daadsmnu.c.  includes collect.c,
*           initgraphics.c initda.c.
*   CONTENTS:  A21 cl1ctdata, A211 presentdacqmnu,
*              A212 processadacqrequest, A2121 read_setup,
*              A2122 interactive_setup.
*   FUNCTION:  This file is the data collection menu
*              file which drives the entire data
*              collection and display subsystem.
*
*****/

```

```

/*****
*
*   DATE:      4 October 1985
*   VERSION:   1.2
*   NAME:      cllctdata
*   MODULE NUMBER:  A21
*   FUNCTION:  Performs the functions for Collect Data &
*              Display. Controls Collect Data & Display
*              menu presentation and accepts the user
*              responses. Branches to A212 processdacq-
*              response to user desired function
*              as indicated by the response.
*
*   INPUTS:   None
*   OUTPUTS:  answer
*   GLOBAL VARIABLES USED:  CLEARSC
*   GLOBAL VARIABLES CHANGED:  None
*   GLOBAL TABLES USED:  None
*   GLOBAL TABLES CHANGED:  None
*   FILES READ:  None
*   FILES WRITTEN:  None
*   MODULES CALLED:  A211 presentdacqmnu,
*                   A212 processdacqrequest
*   CALLING MODULES:  A2 processmainrequest
*   AUTHOR:  Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

```

```

/* print statements for DataAcqmenu menu options */

```

```

#define usestd      "1) Use standard set-up file.\n"
#define interact    "2) Interactive set-up options.\n"
#define coldata     "3) Collect data and display.\n"
#define exitdacq    "4) Exit menu.\n"
#define DEXIT "4"
int ready = 0;

```

```

cllctdata()
{
    char answer[2];
    char temp;
    do
    {
        printf(CLEARSC);
        sleep(SNOOZE);
        presentdacqmnu();
        scanf("%s", answer);
        temp = getchar();
        processdacqrequest(answer);
    }
    while (answer[0] != DEXIT);
}
/* end cllctdata */

```



```

/*****
*
*   DATE:      4 October 1985
*   VERSION:   1.1
*   NAME:      presentdacqmenu
*   MODULE NUMBER:  A211
*   FUNCTION:  Presents the Collect Data & Display menu.
*               The user is given four choices: read
*               set-up file, interactive set-up, collect
*               and store data, & exit back to main menu.
*   INPUTS:    None
*   OUTPUTS:   None
*   GLOBAL VARIABLES USED:  afit, sysname, dacqmenu, CR,
*                           usestd, interact, coldata,
*                           exitdacq.
*   GLOBAL VARIABLES CHANGED:  None
*   GLOBAL TABLES USED:      None
*   GLOBAL TABLES CHANGED:   None
*   FILES READ:                None
*   FILES WRITTEN:             None
*   MODULES CALLED:            None
*   CALLING MODULES:           A21 cllctdata
*   AUTHOR:                    Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/
presentdacqmenu()
{
printf("                ");
printf(afit);
printf("                ");
printf(sysname);
printf("                ");
printf(dacqmenu);
printf(CR);
printf(CR);
printf("Please examine the menu below and indicate the type
      of operation\n");
printf("you wish to perform. \n");
printf(CR);
printf("Data Collection and Display Menu:  \n");
printf(CR);
printf(usestd);
printf(interact);
printf(coldata);
printf(exitdacq);
printf(CR);
printf(CR);
printf(CR);
printf("Please indicate choice by typing in corresponding
      number above:  ");
} /* end presentmenu */

```

```

/*****
*
*   DATE:      4 October 1985
*   VERSION:   1.2
*   NAME:      processdacrequest
*   MODULE NUMBER:  A212
*   FUNCTION:   Determines the function selected by
*               the user and then branches to the proper
*               routine.  If the selection is valid, a
*               branch occurs, if not, an error message
*               is given and the Collect Data & Display
*               menu returns to the screen. This happens
*               until a valid response is received.
*
*   INPUTS:    answer
*   OUTPUTS:   None
*   GLOBAL VARIABLES USED:  None
*   GLOBAL VARIABLES CHANGED:  None
*   GLOBAL TABLES USED:  None
*   GLOBAL TABLES CHANGED:  None
*   FILES READ:  None
*   FILES WRITTEN:  None
*   MODULES CALLED:  A2121 read_setup,
*                   A2122 interactive_setp,
*                   A2123 initgraphics,
*                   A2124 initda,
*                   A2125 collectdata.
*   CALLING MODULES:  A21 cllctdata
*   AUTHOR:   Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

```

```

/* these defines go with the data acquisition routines */
/* and are global within the cllctdata subsystem */

```

```

#define EXREAD      1
#define EXWRITE     0
#define NBUFFERS    90
#define BUFFSIZE    215
#define calcbuffsz  192

short acqbuff[NBUFFERS][BUFFSIZE];
short pinmask = 0xffff;
short *bp;
static int pathnum = -1;
char FILEOUT[30];
char fchanodr[30];
int error;
int NBUFFITEMS;
int nframes;
int nchans;
int ndispchans;

```

```

int DISPPPOINTS= 110; /*dispbuffsize global in dadsmnu.c*/
short offset;
int data_flag;
int chanorder[16] ;
int c;

/* reduction data structures */

int reduction_count[16] = {0}; /* input from channel order
                                file */

int dataitem_count[16] = {0}; /* incremented to reduction
                                count then reset to 0 */
static int end_list[250];

/* include submodules A2123, A2124, and A2125 */

#include "initgraphics.c"
#include "initda.c"
#include "collect.c"

processdacqrequest(n)

char *n;
{
    c = n[0];

    switch(c)
    {
        case '1': {
            ready = read_setup(&data_flag,&nchans,
                              &ndispchans,fchanodr,FILEOUT);
            break;
        }
        case '2': {
            ready = interactive_setup(&data_flag,
                                      &nchans,&ndispchans,fchanodr,
                                      FILEOUT);
            break;
        }
    }
}

```

```

    case '3': {
        if(ready ==1)
        {
            error = 0; /* start with no error */
            error = initgraphics(nchans,ndispchans,
                                fnchanodr,chanorder);

            if (!error)
                error = initda(data_flag,nchans,chanorder);
            if (!error)
                collectdata(data_flag);
            break;
        }
        else /* If there is an error in set-up */
        {
            printf("Set-up not completed.");
            printf(" Choose 1 or 2  \n");
            sleep(SNOOZE*2);
            break;
        }
    }
    case DEXIT: {
        printf("Goodbye\n");
        break;
    }
    default: {
        printf(TRYAGAIN);
        sleep(SNOOZE);
        break;
    }
}
sleep(SNOOZE);

} /* end processdacqrequest */

```

```

/*****
*
*   DATE:      4 October 1985
*   VERSION:   1.2
*   NAME:      read_setup
*   MODULE NUMBER:  A2121
*   FUNCTION:   Reads from a user given file the
*               set-up parameters, data_flag, nchans,
*               ndispchans, fnchanodr, and FILEOUT. Asks
*               for a Session header name then will
*               write the Session Header file using
*               that name for a file name.
*   INPUTS:    data_flag, nchans, ndispchans, fnchanodr,
*               FILEOUT
*   OUTPUTS:   data_flag, nchans, ndispchans, fnchanodr,
*               FILEOUT
*   GLOBAL VARIABLES USED:  None
*   GLOBAL VARIABLES CHANGED:  None
*   GLOBAL TABLES USED:  None
*   GLOBAL TABLES CHANGED:  None
*   FILES READ:  None
*   FILES WRITTEN: Session Header file containing
*                  same as outputs
*   MODULES CALLED:  None
*   CALLING MODULES:  A212 processdacrequest
*   AUTHOR:  Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

```

```

read_setup(pdata_flag,pnchans,pndispchans,fnchanodr,FILEOUT)

```

```

int *pdata_flag,*pnchans,*pndispchans;
char FILEOUT[],fnchanodr[];

```

```

{

```

```

#define MAXLINE 100
#define MINUSONE -1
FILE *fp,*fopen();
char setup_fn[30];
char line[MAXLINE];
char tempchar;
char anschar[2];
char session_file[30];
char number[MAXLINE];
char blanks[30];
int fd;
int n;
int done;

```

```

/***** BEGIN READ SETUP *****/

/* initialize some variables */

for (n=0;n<30;n++)
    blanks[n] = ' ';
strcpy(blanks,setup_fn);
strcpy(blanks,fnchanodr);
strcpy(blanks,FILEOUT);
*pnchans = 0;
*pn dispchans = 0;
*pdata_flag = 0;

do /* the entire module is a big loop */
{
printf(CLEARSC);
printf("Use standard set_up file\n");
printf(CR);
printf(CR);

/* get the set up file name and test for existence */
do
{
printf("Please give the name of the standard set_up file. 20
characters max.\n");
scanf("%s",setup_fn);
tempchar = getchar();
if(setup_fn[0] == '\0') /* abnormal exit, return to menu */
return(-1);

/* test for file existence */

if((fp = fopen(setup_fn,"r")) == NULL)
{
printf("Set_up file %s does not exist\n",setup_fn);
done = FALSE;
}
else
{
done = TRUE;
}
}
while (!done);

sleep(1);

```

```

/* nchans */

if((fgets(line,MAXLINE,fp)) !=NULL)

{
    for(n=0;(line[n] != '\n');n++)

        number[n] = line[n];

    *pnchans = atoi(number);

    if(*pnchans < 1 || *pnchans > 16 )

        {
            printf("number of channels input %d is out
                of range\n", *pnchans);
            printf("Return to menu\n");
            printf(HITRETURN);
            scanf("%c",&tempchar);
            return(-1);
        }

    else

        {
            printf("Number of channels to collect
                is -- %d\n",*pnchans);
        }

}

else

{
    printf("Set_up file does not have all the required
        parameters\n");
    printf("Return to menu\n");
    printf(HITRETURN);
    scanf("%c",&tempchar);
    return(-1);
}

/* ndispchans number of display channels */

sleep(1);
if((fgets(line,MAXLINE,fp)) !=NULL)
{
    for(n=0;(line[n] != '\n');n++)
        number[n] = line[n];
    *pndispchans = atoi(number);
    if(*pndispchans > *pnchans || *pndispchans > 12 )
        {
            printf("number of display channels exceed
                the number of\n");
            printf("input channels or the max number of
                display channels.\n");
        }
}

```

```

        printf(CR);
        printf("Return to menus\n");
        printf(HITRETURN);
        scanf("%c",&tempchar);
        return(-1);
    }
    else
    {
        printf("Number of channels displayed
               is -- %d\n",*pndispchans);
    }
}
else
{
    printf("Set_up file does not have all the required
           parameters\n");
    printf("Return to menus\n");
    printf(HITRETURN);
    scanf("%c",&tempchar);
    return(-1);
}

/* data_flag the mode of data collection */

sleep(1);

if((fgets(line,MAXLINE,fp)) !=NULL)
{
    for(n=0;(line[n] != '\n');n++)
        number[n] = line[n];
    *pdata_flag = atoi(number);
    if(*pdata_flag < 1 || *pdata_flag > 2 )
    {
        printf("Inconnect collection mode detected\n");
        printf("Return to menus\n");
        printf(HITRETURN);
        scanf("%c",&tempchar);
        return(-1);
    }
    else /* If collection mode is given as 1 or 2 */
    {
        if(*pdata_flag == 1)
            printf("Collection mode is --
                   parallel.\n");
        else /* (*pdata_flag == 2) */
            printf("Collection mode is --
                   analog.\n");
    }
}

```



```

else /* The data collection mode information is missing */
{
    printf("Set_up file does not have all the required
           parameters\n");
    printf("Return to menus\n");
    printf(HITRETURN);
    scanf("%c",&tempchar);
    return(-1);
}

/* Session Header file name will hold these parameters for
   later replay */

sleep(1);
if((fgets(line,MAXLINE,fp)) !=NULL)
{
    for(n=0;(line[n] != '\n');n++)
        session_file[n] = line[n];
    session_file[n] = '\0';

    if((fd=open(session_file,0)) != MINUSONE) /* use
        open not fopen because open does not create the
        file if it does not already exist. */

    {
        printf(CR);
        printf("Session header file %s already exists.\n",
               session_file);
        do
        {
            printf(" \n          Overwrite current
                    contents, Y or N.\n");
            scanf("%s",anschar);
            tempchar = getchar();
            if(anschar[0]== '\0')
                return(-1); /* abnormal exit from set_up
                             with setup not complete */
        }
        while((anschar[0] != 'Y' && anschar[0] != 'Y')
              && (anschar[0] != 'n' && anschar[0] != 'N'));
        /* The statement above causes this loop to keep cycling
           until a valid response (Y,y,N,n) is received. */

        if(anschar[0] == 'n' || anschar[0] == 'N')
        {
            printf("Return to menus\n");
            printf(HITRETURN);
            scanf("%c",&tempchar);
            return(-1);
        }
    }
}

```

```

        else /* a valid response is given */
        {
            close(fd); /* close the session file */
            printf("Session Header file name is --
                    %s\n",session_file);
        }
    else
    {
        printf("Session Header file name is --
                %s\n",session_file);
    } /* end if == MINUSONE */
}
else /* if data is missing from the session file */
{
    printf("Set_up file does not have all the required
            parameters\n");
    printf("Return to menus\n");
    printf(HITRETURN);
    scanf("%c",&tempchar);
    return(-1);
}

/* FILEOUT the output file containing the binary
   collected data */

sleep(1);
if((fgets(line,MAXLINE,fp)) !=NULL)
{
    for(n=0;(line[n] != '\n');n++)
        FILEOUT[n] = line[n];
    FILEOUT[n] = '\0';
    if((fd=open(FILEOUT,0)) != MINUSONE) /* use open
        not fopen because open does not create the
        file if it does not already exist */
    {
        printf("Output file %s already exists.
                \n",FILEOUT);
        do
        {
            printf(" \n Overwrite current
                    contents, Y or N.\n");
            scanf("%s",&anschar);
            tempchar = getchar();
        } if(anschar[0]!='\0')
            return(-1); /* abnormal exit from set up
                        with setup not complete */
        while((anschar[0] != 'Y' && anschar[0] != 'y')
            && (anschar[0] != 'N' && anschar[0] != 'n'))

```

```

        if(anschar[0] == '\n' || anschar[0] == '\N')
        {
            printf("Return to menu\n");
            printf(HITRETURN);
            scanf("%c",&tempchar);
            return(-1);
        }
    else
    {
        close(fd); /* close output file */
        printf("Output file is
                -- %s\n",FILEOUT);
    }
}
else
{
    printf("Output file is
            %s\n",FILEOUT);
} /* end if == MINUSONE */
}

else
{
    printf("Set up file does not have all the required
            parameters\n");
    printf("Return to menu\n");
    printf(HITRETURN);
    scanf("%c",&tempchar);
    return(-1);
}

/* Channel order file, contains the list of channels to be
   collected and the secondary reduction factors for each
   channel. */

sleep(1);
if((fgets(line,MAXLINE,fp)) !=NULL)
{
    for(n=0;(line[n] != '\n');n++)
        fnchanodr[n] = line[n];
    if((fd = open(fnchanodr,0)) == MINUSONE) /* use open
        not fopen because open does not create the file
        if it does not already exist */

    {
        printf("Channel order file %s does not
                exist.\n",fnchanodr);
        printf("Return to menu\n");
        printf(HITRETURN);
        scanf("%c",&tempchar);
        return(-1);
    }
}

```

```

        else
        {
            close(fd);
            printf("Channel order file name is    --
                  %s\n", fnchanodr);
        } /* end if == MINUSONE */
    }
else
{
    printf("Set_up file does not have all the required
           parameters\n");
    printf("Return to menus\n");
    printf(HITRETURN);
    scanf("%c",&tempchar);
    return(-1);
}
printf("\nAre thses set_up parameters correct?  Y or N \n");

scanf("%s",anschar);
tempchar = getch();
}
while(anschar[0] != 'Y' && anschar[0] != 'y');

/* write session_file onto disk under name given by user */
printf(CLEARSC);
printf("Writing out the Session header file to %s\n",
       session_file);
if((fp=fopen(session_file,"w")) == NULL) /* use fopen now so
    can use fprintf to output parameters */
{
    printf("Could not write to Session header file %s\n",
          session_file);
    printf("Parameters for set-up not stored.....\n");
}
else
{
    fprintf(fp,"%d %d %d %s %s\n",*pdata_flag,
        *pnchans,*pndispchans,fnchanodr,FILEOUT);

    fclose(fp);
}
return(1); /* set up complete if even get this far */
}

```

```

/*****
*
*   DATE:      4 October 1985
*   VERSION:   1.2
*   NAME:      interactive_setup
*   MODULE NUMBER:  A2122
*   FUNCTION:   Interactively asks user for the set-up
*               parameters, data_flag, nchans, ndispchans,
*               fnchanodr, and FILEOUT.  Asks for a Session
*               header name then will write the Session
*               Header file using that name for a file name.*
*   INPUTS:    data_flag, nchans, ndispchans, fnchanodr,
*               FILEOUT
*   OUTPUTS:   data_flag, nchans, ndispchans, fnchanodr,
*               FILEOUT
*   GLOBAL VARIABLES USED:  None
*   GLOBAL VARIABLES CHANGED:  None
*   GLOBAL TABLES USED:  None
*   GLOBAL TABLES CHANGED:  None
*   FILES READ:  None
*   FILES WRITTEN:  Session Header file containing same as
*                   outputs
*   MODULES CALLED:  None
*   CALLING MODULES:  A212 processdacqrequest
*   AUTHOR:  Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

```

```

int interactive_setup(pdata_flag,pnchans,pndispchans,
                    fnchanodr,FILEOUT)

```

```

int *pdata_flag,*pnchans,*pndispchans;

```

```

char FILEOUT[],fnchanodr[];

```

```

{

```

```

#define MINUSONE    -1

```

```

int fd,goodfile;
char numnchans[4];
char numdispchans[4];
char numdata_flag[4];
char anschar[2];
int parameterok;
char SESSIONFILE[30];
FILE *fp,*fopen();

```

```

/* zero out data_flag, nchans, ndispchans to start fresh
everytime */

    *pdata_flag = 0;
    *pnchans = 0;
    *pndispchans = 0;

/* present questions */

do
(
    /* this entire module is a big loop */
    printf(CLEARSC);
    printf("          Interactive set-up options\n");
    printf(CR);
    printf(CR);
    printf("Please answer the following questions
    carefully.\n");
    printf("\nA zero (0) for any response aborts
    interactive set-up\n");
    printf("BUFFERSIZE = %d\n",BUFFSIZE);

/* data_flag */

    do
    (
        printf(CR);
        printf("What is the collection mode? Parallel(1) or
        Analog(2)?\n");
        printf("Enter 1 for parallel or 2 for analog\n");
        scanf("%s",numdata_flag);
        printf("%s\n",numdata_flag);

        if(numdata_flag[0] == '\0')
            return(-1); /* abnormal exit from set_up
            with setup not complete */

        if(numdata_flag[0] < '1' || numdata_flag[0] > '2')
        (
            printf(TRYAGAIN);
            printf(CR);
        )
        else
        (
            *pdata_flag = atoi(numdata_flag);
            printf("Data collection mode will be
            %d.\n",*pdata_flag);
        )
    )
    while(*pdata_flag < 1 || *pdata_flag > 2);

```

```

/* nchans */

printf(CLEARSC);

do
{
printf(CR);
printf("Collect how many channels? (1..16)  ");
scanf("%s",numnchans);
printf("%s\n",numnchans);

if(numnchans[0] == '\0')
return(-1); /* abnormal exit from set_up
              with setup not complete */
*pnchans = atoi(numnchans);
if(*pnchans < 1 || *pnchans > 16)
{
printf(TRYAGAIN);
printf(CR);
}
else
{
printf("Data will be collected on %d
        channels.\n",*pnchans);
}
}
while(*pnchans < 1 || *pnchans > 16);

/* ndispchans */
printf(CLEARSC);
do
{
printf(CR);
printf("Display how many channels? (1..12)  ");
scanf("%s",numdispchans);
printf("%s\n",numdispchans);
if(numdispchans[0] == '\0')
return(-1); /* abnormal exit from set_up
              with setup not complete */
*pnispchans = atoi(numdispchans);
if(*pnispchans < 1 || *pnispchans > 12)
{
printf(TRYAGAIN);
printf(CR);
}
}

```

```

else /* if the # display channels is 1 - 12 */
{
printf("You have selected %d channels for display.",
      *pndispchans);
if(*pndispchans > *pnchans )
{
printf("\nNumber of Display channels exceeds
      the\n");
printf("      number of input channels.  \n");
printf(TRYAGAIN);
*pndispchans = 0;
}
}
while(*pndispchans < 1 || *pndispchans > 12 ||
      *pndispchans > *pnchans);

/* channel order file */

goodfile = 0;
printf(CLEARSCR);
do
{
printf(CR);
printf("Give the Channelorder file name (20
      characters max)\n");

scanf("%s",fchanodr);
printf("%s\n",fchanodr);
if(fchanodr[0] == '\0')
return(-1); /* abnormal exit from set_up
      with setup not complete */

/* open and close fchanodr to test for its existence */

if((fd=open(fchanodr,0)) == MINUSONE)
{
printf(CR);
printf("Channel order file %s does not
      exist.\n",fchanodr);
printf(TRYAGAIN);
printf(CR);
goodfile = 0;
}
else
{
fclose(fd);
goodfile = 1;
}
}
while(!goodfile);

```



AD-A164 899

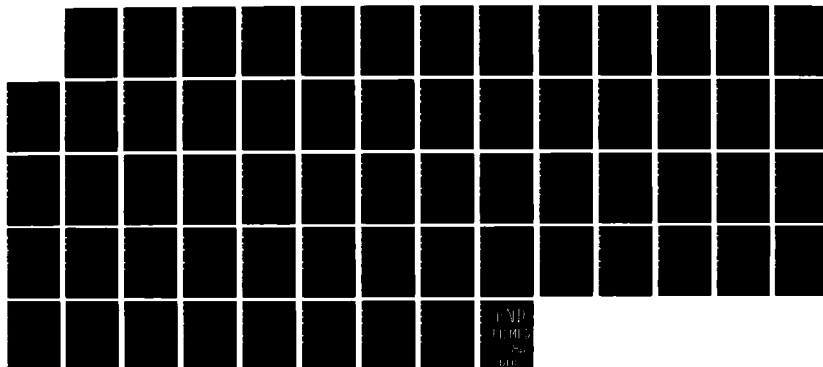
AN ANALYSIS OF POTENTIAL PREDICTIVE PARAMETERS OF  
MOTION SICKNESS USING AAR (U) AIR FORCE INST OF TECH  
WRIGHT-PATTERSON AF OH SCHOOL OF ENGI

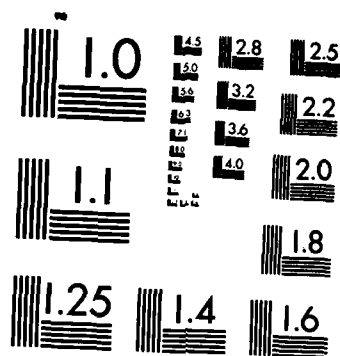
3/3

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MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

```

/*FILEOUT*/

    goodfile = 0;
    printf(CLEARSC);

    do
    {
        printf(CR);
        printf("Give the output file name (20
                characters max)\n");

        scanf("%s",FILEOUT);
        printf("%s\n",FILEOUT);

        if(FILEOUT[0] == '\0')
            return(-1); /* abnormal exit from set_up
                        with setup not complete */
    }

/* open and close FILEOUT to test for its existence */

    if((fd=open(FILEOUT,0)) != MINUSONE)
    {
        printf(CR);
        printf("Output file %s already exists.
                \n",FILEOUT);

        do
        {
            printf("  Overwrite current contents,
                    Y or N.\n");
            scanf("%s",anschar);
            if(anschar[0]== '\0')
                return(-1); /* abnormal exit from set_up
                            with setup not complete */
            tolower(anschar[0]);
        }
        while(anschar[0] != 'y' && anschar[0] != 'n');
        printf(CR);
        if(anschar[0] == 'n')
            goodfile = 0;
        else
            goodfile = 1;
    }
    else
    {
        /* output file does not exist already;
           dont do anything */

        goodfile = 1;
    }
}
while(!goodfile);

```

```

/*Session header file*/
goodfile = 0;
printf(CLEARSC);
do
{
printf(CR);
printf("Give the Session file name (20
characters max)\n");
printf("This file will store these set-up
parameters. \n");
scanf("%s",SESSIONFILE);
printf("%s\n",SESSIONFILE);
if(SESSIONFILE[0] == '\0')
return(-1); /* abnormal exit from set_up
with setup not complete */
/* open and close SESSIONFILE to test for its existence */
if((fd=open(SESSIONFILE,0)) != MINUSONE)
{
printf(CR);
printf("Session header file %s already
exists.\n",SESSIONFILE);
do
{
printf(" Overwrite current contents,
Y or N.\n");
scanf("%s",anschar);
if(anschar[0]== '\0')
return(-1); /* abnormal exit from set_up
with setup not complete */
tolower(anschar[0]);
}
while(anschar[0] != 'y' && anschar[0] != '\n');
printf(CR);
if(anschar[0] == '\n')
goodfile = 0;
else
goodfile = 1;
}
else
{
/* output file does not exist already:
dont do anything */
goodfile = 1;
}
}
while(!goodfile);
parameterok = showparameters(*pdata_flag,*pnchans,
*pn dispchans,fnchanodr, FILEOUT,SESSIONFILE);
}
while(parameterok != 1);

```

```

/* write SESSIONFILE onto disk under name given by user */

printf(CLEARSC);
printf("Writing out the Session header file to %s\n",
      SESSIONFILE);
if((fp=fopen(SESSIONFILE,"w")) == NULL) /* use fopen now so
                                         can use fprintf to output parameters */
{
    printf("Could not write to Session header file %s\n",
          SESSIONFILE);
    printf("Parameters for set-up not stored.....\n");
}
else
{
    fprintf(fp,"%d %d %d %s %s\n",*pdata_flag,*pnchans,
          *pndispchans,fmchanodr,FILEOUT);
    fclose(fp);
}
return(1); /* setup complete */
}

int showparameters(sdata_flag,schans,sndispchans,sfmchanodr,
                  sFILEOUT,sSESSIONFILE)

int sdata_flag;
int schans;
int sndispchans;
char sfmchanodr[];
char sFILEOUT[];
char sSESSIONFILE[];
{
    char anschar[2];
    printf(CLEARSC);
    printf("    The following session parameters have been
          recorded    ");
    printf(CR);
    printf(CR);
    printf("    Number of          Number of          Collection\n");
    printf("    Input channels    Display channels    Mode\n");
    printf(CR);
    printf("          %d          %d          %d\n",
          schans,sndispchans,sdata_flag);

    printf("    Output file\n");
    printf("    %s\n",sFILEOUT);
    printf(CR);
    printf("    Session Header file\n");
    printf("    %s\n",sSESSIONFILE);
    printf(CR);

```

```

printf(" Channel Order file\n");
printf(CR);
printf("          %s\n",sfchanodr);
printf("\n\n\n");
do
{
printf("Is this information correct? y or n \n");
scanf("%s",anschar);
}
while((anschar[0] != 'y' && anschar[0] != 'Y')
      && (anschar[0] != 'n' && anschar[0] != 'N'));
if(anschar[0] == 'y' || anschar[0] == 'Y')
    return(1);
else
    return(-1);
}

/*****          END OF FILE          *****/

```

```

/*****
*
*   DATE:
*   VERSION: 1.2
*   TITLE: Initialize graphics
*   FILENAME: initgraphics.c
*   OWNER: BDAS System Manager
*   SOFTWARE SYSTEM: MASSCOMP
*   OPERATING SYSTEM: Unix version III
*   LANGUAGE: C
*   USE: #included in cllctdata.c, #includes nothing
*   CONTENTS: A2123 initgraphics, A21231 initchanorder,
*             A2132 placewindows, A2133 create_segment
*   FUNCTION: This file contains all the required
*             routines to initialize the MASSCOMP
*             graphics package for the BDAS.
*
*****/

```

```

/*****
*
*   DATE:
*   VERSION: 1.2
*   NAME:  initgraphics
*   MODULE NUMBER:  A2123
*   FUNCTION:  Uses MASSCOMP graphics routines to
*               initialize the graphics processor and
*               graphics display.  Controls the creation
*               and placement of graphics windows ( one
*               for each display channel),and the
*               building of graphics display segments
*               to dynamically display collected data
*               real-time.
*   INPUTS:  nchans,ndispchans,fnchanodr,chanorder,
*             data_flag
*   OUTPUTS:  chanorder
*   GLOBAL VARIABLES USED:  chanlabel, DISPPIONTS,
*                           MAXWINDOWS
*   GLOBAL VARIABLES CHANGED:  realxl, realxr, realyb,
*                               realyt
*   GLOBAL TABLES USED:  None
*   GLOBAL TABLES CHANGED:  None
*   FILES READ:  None
*   FILES WRITTEN:  None
*   MODULES CALLED:  A21231 initchanorder,
*                   A21232 placewindows,
*                   A21233 create_segments
*   CALLING MODULES:  A212 processdacrequest
*   AUTHOR:  Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/
/*  these globals are used within this file  */

int xl,yb,xr,yt,null;
int height,width;
int display_flag[NDISPBUFFS];
double realxl = 0.0;
double realyb = -1.0;
double realxr = 110.0;
double realyt = 1.0;
int xarray[DISPBUFFSIZE]; /* DISPBUFFSIZE is a global in
                           daadsmnu.c */

int fb = 1;
char chanlabel[16][255];
int gray,white;
static int mainseg[1000]; /* arrays to hold segments for
                           graphics processor, 1000 is
                           arbitrary over-kill */

static int displayit[1000];

```



```

/***** begin initgraphics *****/

initgraphics(nchans,ndispchans,fnchanodr,chanorder,data_flag)

int nchans,ndispchans;
int chanorder[];
int data_flag;
char fnchanodr[];

{

int error;
int intx;
double fx,x;
int i,ytop;
double j;

    mgiasngp(0,0); /* put in main */
    mgifetchgf(1,"5x7");

    mgigetvcoord(2,&x1,&yb,&xr,&yt,&null); /* coordinates
                                           for ref window */

    ytop = yt;
    mgifb(1,3); /* display to both frames */

    mgipln(3); /* blank out */
    mgihue(0); /* the */
    mgibox(x1,yb,xr,yt); /* screen */

/* set up static and dynamic color hue sets */

    /*mgidyndisp(1); */
    mgifreesets();
    mgisetqual(0,0,1);
    gray = mgistatset(mgfcns("gray"));
    mgisetqual(0,0,1);
    white = mgistatset(mgfcns("white"));
    mgifixsets();

    mgicm(1,mgfcns("white"));
    mgicm(2,mgfcns("white"));

    /*mgilids(); informs gp0 will have dynamic
    switching of frame buffers */

```

```

/* now determine how many windows from the number of
   channels then place the windows */

```

```

    if(ndispchans <= 4)
    {
        height = yt/ndispchans;
        width = xr;
        yb = yt - height;
        placewindows(3,ndispchans);
    }
    else
    {
        if ( ndispchans <= 6)
        {
            height = yt/3;
            width = xr/2;
            yb = yt - height;
            placewindows(3,3);
            xl = width;
            width = xr;
            yt = ytop;
            yb = yt - height;
            placewindows(6,3);
            width = xr/2;
        }
        else
        {
            if (ndispchans <= 8)
            {
                height = yt/4;
                width = xr/2;
                yb = yt - height;
                placewindows(3,4);
                xl = width;
                width = xr;
                yt = ytop;
                yb = yt - height;
                placewindows(7,4);
                width = xl; /* return width to size of
                           each window */
            }
            else
            {
                if(ndispchans <= 10 )
                {
                    height = yt/5;
                    width = xr/2;
                    yb = yt - height;
                    placewindows(3,5);
                    xl = width;
                    width = xr;
                    yt = ytop;

```

```

        yb = yt - height;
        placewindows(8,5);
        width = xl; /* return width to size of each
            window for use in initializing xarray */
    }
    else
    {
        height = yt/6;
        width = xr/2;
        yb = yt - height;
        placewindows(3,6);
        xl = width;
        width = xr;
        yt = ytop;
        yb = yt - height;
        placewindows(9,6);
        width = xl; /* return width to size of each
            window for use in initializing xarray */

    }
} /* endif */
} /* endif */

} /* endif */

/* initialize the xarray. we want the xarray to represent
the middle 90% of the display window so it will co-incide
with the display grid also in the middle 90% */

x = .05*realxr;
intx = x;
DISPPPOINTS = DISPPPOINTS - (2*intx);
fx = ( (realxr - (2.0 * x))/(float)(DISPPPOINTS));
for(i=0;i<DISPPPOINTS;i++)
{
    xarray[i] = mgrscalex(3,x); /* windo 3 is
                                equal to all window sizes */
    x = x + fx ;
}

mgipln(1); /* turn off the 2nd plane */

```

```

/* now create the display grids and label them */

error = initchorder(fnchanodr,ndispchans,chanorder);

if (!error)
{
    mgihue(3);
    for(i=3;i<(ndispchans+3);i++) /* i is bumped by 3
        for the 0,1,2 system windows we cant use */
    {

        mgiv(i);
        mgrl(.05*realxr,-.95,.05*realxr,.95);
        mgrl(.05*realxr,0.0,.95*realxr,0.0);

        /* the tick marks */

        for (j = -.95;j<.96;j=j+.19)
            mgrl(.05*realxr,j,.06*realxr,j);

        /* print channel labels */
        mgrgfs(.40*realxr,-.95,0,chanlabel[i-3]);

    } /* end for loop for the grids */

    mgipln(2); /* a binary 10 which activates plane 2
                '1' and deactivates plane 1 '0' */

    /* create the segments one for each window to be displayed*/

    /*mgiset(white); erasure of previous line done by
        dynamic sets */

    mgibseg(mainseg,1000);
    for (i=0;i<ndispchans;i++)
    {
        create_segment(i);
    }
    /* mgidci(); */

    mgireturn();

    mgidseg();

    mgibseg(displayit,1000);

    mgacall(mgfadd(mainseg));

    mgas03(3,mgfadd(&fb),mgflit(3),mgfreg(3,0)); /* this
        command does: 3 - fb */
}

```

```

mgafb(mgfadd(&fb),mgfreg(3,0)): /* mgifb(fb,3-fb)*/
mgao2(1,mgfreg(3,0),mgfadd(&fb)): /* fb = 3-fb */
mgwseg(mainseg);
mgidseg();
mgibseg(end_list,250);
mgipln(2);
mgidseg();
mgisegcont(displayit); /* tell graphics processor
                        to continuously execute 'displayit' segment */
return(0);

} /* end if !error */

else
{
mgideagp(0,0);
return(-1); /* initgraphics error */
}

} /****** end initgraphics *****/

```

```

/*****
*
*   DATE:
*   VERSION: 1.2
*   NAME:  initchorder
*   MODULE NUMBER:  A21231
*   FUNCTION:  Reads the channel order file (CHANFILE)
*              to obtain the user desired order of input
*              channels. Also for each channel, reads
*              the supplied label. Channel numbers are
*              two digits long (00,01,02...15). Channel
*              labels are a maximum of 30 characters.
*   INPUTS:  CHANFILE, ndispchans
*   OUTPUTS:  chanorder, returns an error condition flag
*   GLOBAL VARIABLES USED:  chanlabel, HITRETURN
*   GLOBAL VARIABLES CHANGED:  chanlabel
*   GLOBAL TABLES USED:  None
*   GLOBAL TABLES CHANGED:  None
*   FILES READ:  CHANFILE - contains the file name given
*                by the user
*   FILES WRITTEN:  None
*   MODULES CALLED:  None
*   CALLING MODULES:  A2123 initgraphics
*   AUTHOR:  Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

```

```

int initchorder(CHANFILE,ndispchans,chanorder)

```

```

char CHANFILE[];
int ndispchans;
int chanorder[];

```

```

{

```

```

#define MAXLINE 100

```

```

char channum[2];
char channame[255];
char line[MAXLINE];
int i,n,j;
FILE *fp, *fopen();
char tempchar;
char reducenum[4];

```

```

if((fp=fopen(CHANFILE,"r")) == NULL)
{
    printf("cant open chanorder file  %s\n",
           CHANFILE);
    printf(HITRETURN);
    scanf("%c",&tempchar);
    return (-1);
}
else
{
    for(i=0;i<ndispchans;i++)
    {
        if((fgets(line,MAXLINE,fp)) != NULL)
        {
            for (n=0;(line[n] != '\n');n++)
                channum[n] = line[n];
            chanorder[i] = atoi(channum);
            if(chanorder[i] > 15 || chanorder[i] < 0)
            {
                printf("Channel number %d in channel
                       order",chanorder[i]);
                printf("file out of range\n");
                printf(HITRETURN);
                scanf("%c",&tempchar);
                return(-1);
            }
            n++; /* advance n past the blank */
            for (j=0;(line[n] != '\n');n++,j++)
                reducenum[j] = line[n];
            reduction_count[i] = atoi(reducenum);
            n++; /* advance n past the blank */
            for (j=0;(line[n] != '\n');n++,j++)
                channame[j] = line[n];
            channame[j] = '\0';
            strcpy(chanlabel[i], channame);
        }
    }
    else
    {
        printf("Not enough channel numbers in
               chanorder file\n");
        printf(HITRETURN);
        scanf("%c",&tempchar);
        fclose(fp);
        return(-1);
    }
    fclose(fp);
}

return(0); /* no errors in initchanorder */
}

/***** END OF FILE *****/

```

```

/*****
*
*   DATE:
*   VERSION: 1.2
*   NAME: placewindows
*   MODULE NUMBER: A21232
*   FUNCTION: Uses MASSCOMP unique graphics routines to
*             define and place graphics windows. Each
*             window will display data from a single
*             channel.
*   INPUTS: start - the first window number to be
*             defined
*            howmany - how many windows to define
*                    beginning at start
*   OUTPUTS: None
*   GLOBAL VARIABLES USED: xl, yb, width, yt, realxl,
*                          realyb, realxr, realyt
*   GLOBAL VARIABLES CHANGED: None
*   GLOBAL TABLES USED: None
*   GLOBAL TABLES CHANGED: None
*   FILES READ: None
*   FILES WRITTEN: None
*   MODULES CALLED: None
*   CALLING MODULES: A2123 initgraphics
*   AUTHOR: Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

placewindows(start,howmany)

int start,howmany;

(
int i;
  for (i = start;i<(howmany+start);i++)
  (
    mgidefw(i);
    mgipw(i,2,xl,yb,width,yt);

    mgrvcoor(i,realxl,realyb,realxr,realyt);

    /*mgiv(i);
    mgibox(xl,yb,width,yt); */

    yt = yb;
    yb = yt - height;

  )
  return;
) /***** end placewindows *****/

```



```

/*****
*
*   DATE:
*   VERSION: 1.2
*   NAME: create_segment
*   MODULE NUMBER: A21233
*   FUNCTION: Uses MASSCOMP unique graphics routines to
*             create a graphics segment. Segments are
*             created and used because of a MASSCOMP
*             feature to constantly display segments
*             independantly of the host or data
*             acquisition processors.
*   INPUTS: dispbuff - integer, identifies the display
*            segment #
*   OUTPUTS: None
*   GLOBAL VARIABLES USED: DISPPPOINTS, display_buff
*   GLOBAL VARIABLES CHANGED: None
*   GLOBAL TABLES USED: None
*   GLOBAL TABLES CHANGED: None
*   FILES READ: None
*   FILES WRITTEN: None
*   MODULES CALLED: None
*   CALLING MODULES: A2123 initgraphics
*   AUTHOR: Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

```

```

create_segment(dispbuff)

int dispbuff;
{
    mgiv(dispbuff+3);

    mgihue(0); /* color 0 = Black */
    mgibox(0,0,1000,1000);
    mgihue(3);

    /* put a 1 into the display buffers display flag to show
       being displayed */
    mgaao2(1,mgflit(1),mgfadd(&display_flag[dispbuff]));

    mgals(mgfadd(&DISPPPOINTS), mgfadd(xarray),
          mgfadd(&display_buff[dispbuff][0]));

    /* clear the display flag */

    mgaao1(18,mgfadd(&display_flag[dispbuff]));

} /* end create_segment */

```

```

/*****
*
*   DATE:
*   VERSION: 1.2
*   TITLE: Initialize the data acquisition ports
*   FILENAME: initda.c
*   OWNER: BDAS System Manager
*   SOFTWARE SYSTEM: MASSCOMP
*   OPERATING SYSTEM: Unix version III
*   LANGUAGE: C
*   USE: #included inside clctdata.c, includes nothing
*   CONTENTS: initda()
*   FUNCTION: This file contains a single submodule for
*             inclusion with the DAADS module clctdata()
*
*****/

```

```

/*****
*
*   DATE:
*   VERSION:  1.2
*   NAME:  initda
*   MODULE NUMBER:  A2124
*   FUNCTION:  Sets up either the parallel or analog
*               data and for analog open a path, set-up
*               clocks, identify clock frequency.  For
*               multichannel analogy, set-up two clocks
*               for collection of frames of channels.
*               Currently, analog collection is in
*               MASSCOMP incremental mode (0,1,2,...).
*               A random mode is available but fails to
*               work for reasons unknown.
*   INPUTS:  data_flag, nchans, chanorder
*   OUTPUTS:  None
*   GLOBAL VARIABLES USED:  NBUFFERS, acqbuff, pinmask
*   GLOBAL VARIABLES CHANGED:  NBUFFITEMS, nframes,
*                               pathnum, bp
*   GLOBAL TABLES USED:  None
*   GLOBAL TABLES CHANGED:  None
*   FILES READ:  None
*   FILES WRITTEN:  None
*   MODULES CALLED:  None
*   CALLING MODULES:  A212 processdacrequest
*   AUTHOR:  Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

```

```

/* begin initda */

initda(dflag,chans,chanorder)
int chans,dflag,chanorder[];

(
#define NEAREST 0
#define SQUARE 4
#define LOW 0
#define BIPOLAR 0
#define UNIPOLAR 1
#define SINGLEENDED 0
#define FIRSTCLOCK "/dev/dacp0/c1k0"
#define SINCLOCK "/dev/dacp0/c1k1"
#define FREQ1CLK 160.0 /* change this to change the
                        analog clock rate */
#define FREQ2CLK 10000.0

double nframes;
double freq,rfreq,wret,bfret;

```

```

int frtpanel = 0;
int bnearest = 0;
int ad_gain = 0 ;
int i;
short cgarrray[16]; /* chan gain pairs for mradran */
int cparrray[2];
int clkpna = -1;
int clkpnb = -1;

    nframes = (float)calcbuffsz/(float)chans;
    nframes = round(nframes);

/* this conditional statementy makes the number of frames
even. Then the number of items collected is always even -
a requirement of MASSCOMP DACQ */

    nframes = (nframes % 2) ? nframes + 1 : nframes;
/*printf("nframes = %4f, nframes = %d\n",nframes,nframes);
printf("chans = %d\n",chans); */
    NBUFFITEMS = nframes* chans;

    if(dflag == 1)
/* init parallel paths */
    {
        mropen(&pathnum,"/dev/dacp0/pdi0",EXREAD);
        mrpdmmod(pathnum,pinmask);
    }
    else
    {

        /* init analog, not as simple as parallel */

        mropen(&pathnum,"/dev/dacp0/adf0",EXREAD);

        mrclkopn(&clkpna,FIRSTCLOCK,EXWRITE);

        if (chans == 1 )
        {
            mrclk1(clkpna,NEAREST,FREQ1CLK,&rfreq,SQUARE,
0.0,&wret,LOW);
            mradinc(pathnum,0,1,0,ad_gain);
            mrclktrig(pathnum,1,clkpna);
            mradmod(pathnum,BIPOLAR,SINGLEENDED);
        }
        else
        {

            mrclkopn(&clkpnb,SNDCLOCK,EXWRITE);
            mradmod(pathnum,BIPOLAR,SINGLEENDED);

```

```

        /* initialize the cgarray from the chan order
           array */

        for (i=0;i<chans;i+=2)
        {
            cgarray[i] = chanorder[i];
            cgarray[i+1] = ad_gain;
        }

        /*mradrn(pathnum, chans,cgarray); */
        mradinc(pathnum,0,chans,1,ad_gain);

        cparray[0] = clkpna;
        cparray[1] = clkpnb;

        mrclk2(clkpna,clkpnb,frtpanel,NEAREST,
            FREQ1CLK,&freq,bnearest,FREQ2CLK,&bfret,
            chans,LOW);

        mrclktrig(pathnum,2,cparray);

    }
}

/* end clock and channel converter initializing.
   now initialize the input buffers. Identify and release
   all but the last buffer which is released by the service
   routine in cllctdata. */

for (bp = acqbuff[0];bp< acqbuff[INBUFFERS-1];bp+= BUFFSIZE)
{
    mrbufid(pathnum,bp,BUFFSIZE*sizeof(short));
    mrbufrel(pathnum,bp);
}

/* identify the last buffer */

mrbufid(pathnum,bp,BUFFSIZE*sizeof(short));

} /****** end initda *****/

```

```

#include <math.h>    /* system math file */

int round(x)        /* rounding function  returns x as int */
double x;
{
    int value;
    float value2;

    if(((value = ceil(x)) - x) < 0.5000)
        return(value);
    else
        return(value = floor(x));
}
/***** END OF FILE *****/

```

```

/*****
*
*   DATE:
*   VERSION: 1.2
*   TITLE: Data collection subsystem
*   FILENAME: collect.c
*   OWNER: BDAS System Manager
*   SOFTWARE SYSTEM: MASSCOMP
*   OPERATING SYSTEM: Unix version III, release 2.1b
*   LANGUAGE: C
*   USE: #included in cllctdata.c, includes nothing
*   CONTENTS: collectdata, para_collect, analog collect
*   FUNCTION: These three routines to the actual data
*             collection for either analog or parallel
*             collection. They control the input
*             buffers, display buffers, data reduction
*             and storing data to disk.
*
*****/

```

```

/*****
*
*   DATE:
*   VERSION: 1.2
*   NAME: collectdata
*   MODULE NUMBER: A2125
*   FUNCTION: Opens the output file FILEOUT. If cant
*             returns error message then branches back
*             to clctdata menu. Starts the data
*             transfer based on data_flag, 1 = parallel
*             (digital), 2 = analog mode of transfer.
*   INPUTS: data_flag
*   OUTPUTS: None
*   GLOBAL VARIABLES USED: FILEOUT, pathnum, NBUFFITEMS,
*                         SNOOZE
*   GLOBAL VARIABLES CHANGED: None
*   GLOBAL TABLES USED: None
*   GLOBAL TABLES CHANGED: None
*   FILES READ: None
*   FILES WRITTEN: None
*   MODULES CALLED: A21251 para_collect,
*                  A21252 analog_collect
*   CALLING MODULES: A212 processdacrequest
*   AUTHOR: Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

```

```

#define TIMEOUT 6000
#define PMODE 0644
int fout;
int i,z;
int ripple_flag[NDISPBUFFS];
double data_scaled;
short int data_item[12];
int buffptr;
char stopchar[2];
int prim_reduce;
int write_flag;
int *bp2,*bp3;
int endcount;
int done;
int framechans;
collectdata(data_flag)
int data_flag;
{
#define TRUE 1
#define FALSE 0
char tempchar;

```



```

extern      para_collect();
extern      analog_collect();

done = FALSE;

write_flag = 0; /* starts by not writing to
                  file FILEOUT */

if ((fout = creat(FILEOUT,PMODE)) == -1)
{
    printf("ERROR, can not open output
           file %s\n",FILEOUT);
    printf(HITRETURN);
    scanf("%c",&tempchar);
    return;
}

if (data_flag == 1)/*Parallel(digital)data*/
{
    if(nchans == 1)
    {
        nframes = 96;
        nchans = 2;
        framechans = 1;
    }
    else
        framechans = nchans;

    endcount = 0;
    mxinq(pathnum,NBUFFITEMS,endcount,
          para_collect);

    do
    {
        printf(CLEARSC);
        sleep(1);
        printf("W -Begins/ends writing\n");
        printf("Q -Quits data collection session\n");
        if(write_flag)
            printf("writing to disk file %s\n",FILEOUT);
        scanf("%s",stopchar);
        if(stopchar[0] == 'w' || stopchar[0] == 'W' )
            write_flag = (write_flag == 1) ? 0 : 1;
        if(stopchar[0] == 'q' || stopchar[0] == 'Q')
            done = TRUE;
    }
    while(!done);
    write_flag = 0; /* stops writing to disk */

    /*mnewt(pathnum,0,TIMEOUT); */

```

```

/* The above command tells the data
   acquisition program to wait until the
   data transfer to the storage device is
   complete */

mgihalt disp(3);
mgiseg(end_list);
mgiwseg(end_list);
for(i=0;i<16;i++)
    dataitem_count[i]= 0;

sleep(SNOOZE*2);
close(fout);
/*mrstop(pathnum,1,termstat); */

/* The above command is normally used to stop the data
   transfer, however it was not implemented with the
   current software version (see Software Release Notes,
   DA/CP Software Library Release Notes, page 12). Normally
   it must be done before the data acq devices can be
   closed. 'termstat' in this pgm is a dummy variable. */

mnclosall();

mgideaq(0,0);

printf("Leaving DAADS\n");
exit(1);
}
else /* If data_flag = 2 (analog data) */
{
    if(nchans == 1)
    {
        nframes = 96;
        nchans = 2;
        framechans = 1;
    }
    else
        framechans = ndispchans;

    endcount = 0;
    mrxing(pathnum, NBUFFITEMS, endcount,
           analog_collect);

    do
    {
        printf(CLEARSC);
        sleep(1);
        printf("W -Begins/ends writing\n");
        printf("Q -Quits data collection session\n");
    }

```

```

        if(write_flag)
            printf("writing to disk file %s\n",
                FILEOUT);
        scanf("%s",stopchar);
        if(stopchar[0] == 'w' || stopchar[0] == 'W')
            write_flag = (write_flag == 1) ? 0:1;
        if(stopchar[0] == 'q' || stopchar[0] == 'Q')
            done = TRUE;
    }
    while(!done);
    write_flag = 0; /* stops writing to disk */

    mgihaltdisp(3);
    mgiuseq(end_list);
    mgiwseq(end_list);
    for(i=0;i<16;i++)
        dataitem_count[i] = 0;

    sleep(SNOOZE*2);
    close(fout);
    /*mrstop(pathnum,1,termstat); (see the
        comment above regarding this command */

    mnclosall();
    mgideagp(0,0);
    printf("Leaving DAADS\n");
    exit(1);
}

) /***** end collectdata *****/

```

```

/*****
*
*   DATE:
*   VERSION: 1.2
*   NAME: para_collect
*   MODULE NUMBER: A21251
*   FUNCTION: Process the collected parallel data.
*             Separates channels into display buffers
*             while doing data reduction (1/nchans).
*             Scales data for display. Writes collected
*             data to FILEOUT. This routine is called
*             from inside a DA/CP routine(mrxinq)
*             whenever an inputs buffer is filled.
*
*   INPUTS: None
*   OUTPUTS: None
*   GLOBAL VARIABLES USED: pathnum, nframes, NBUFFITEMS,
*                          bp, nchans, ndispchans, fout,
*                          DISPPPOINTS, FILEOUT,
*                          display_buff.
*
*   GLOBAL VARIABLES CHANGED: fout
*   GLOBAL TABLES USED: None
*   GLOBAL TABLES CHANGED: None
*   FILES READ: None
*   FILES WRITTEN: FILEOUT
*   MODULES CALLED: None
*   CALLING MODULES: A2125 collectdata
*   AUTHOR: Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/
para_collect()

```

```

{

int J,m,K;
short data_temp;
unsigned short channum;

mrbuflnel(pathnum,bp);
mrbuflget(pathnum,0,&bp);

buffptr = 0;
for (K=0;K<nframes;K+=nchans)
{
    for (J=0; J < framechans ; J++)
    {
        channum = bp[buffptr] & 0xf000; /* mask
            with an int 2 byte long value */

        channum = (channum >> 12);
        m = channum;
        if (m < ndispchans)

```

```

/* scale data and place in data_item for placement with
   display_buff */

{

    if(dataitem_count[m] >= reduction_count[m]-1)

        data_temp = bp[bufptr] & 0xffff;
        data_temp = 2048 - data_temp ;
        data_scaled = ((float)(data_temp)
                       /2048.0);

/* parallel in from CIM is unipolar from 0 - 4096 values,
   2048 minus chain input brings input between -2048 and +2048
   then divide by 2048.0 to scale data into the display
   window set at a relative -1.0 to +1.0 in x-plot values.
   Offset of .95 accounts for margins in the grid plot. */

        data_item[m] = mgrscale((m+3),
                                (.95*data_scaled));

/* ripple this buffer dont worry about graphics accessing
   buffer at same time. The more channels displayed the
   less likely to happen, since more channels slows down
   the graphics processor */

        bp2 = display_buff[m];
        bp3 = bp2 +1;
        for(i=0;i<DISPPPOINTS-1;i++)
        {
            *bp2++= *bp3++;
        }
        display_buff[m][DISPPPOINTS - 1] =
            data_item[m];

        dataitem_count[m] = 0;

    }

else
{
    dataitem_count[m] = dataitem_count[m] +1;
} /* end if data_count */

} /* end if m< ndispchans */

```

```

buffptr = buffptr + 1;

} /* end for J */

/* skip over frames for data reduction. Number of frames
   skipped = nchans - 1. Means if have 5 channels per frame
   first frame processed by J loop then skip 4 frames. */

buffptr= buffptr + (nchans*nchans) - framechans;

} /* end for K */

/*write buffer to output */

if(write_flag)
    if (write(fout,bp,(NBUFFITEMS*2)) != NBUFFITEMS*2)
    {
        printf("ERROR-can not finish writing to
               output ");
        printf("%s \n",FILEOUT);
        sleep(SNOOZE);
        return;
    }

} /* end para_collect */

```

```

/*****
*
*   DATE:
*   VERSION: 1.2
*   NAME: analog_collect
*   MODULE NUMBER: A21252
*   FUNCTION: Process collected analog data. Separates
*             channels into individual display buffers
*             while doing data reduction of (1/nchans).
*             Scales data to fit into display window.
*             Writes data to output file FILEOUT
*
*   INPUTS: None
*   OUTPUTS: None
*   GLOBAL VARIABLES USED: pathnum, nframes, NBUFFITEMS,
*                          bp, fout, DISPPPOINTS, FILEOUT,
*                          nchans, ndispchans,
*                          display_buff
*   GLOBAL VARIABLES CHANGED: fout
*   GLOBAL TABLES USED: None
*   GLOBAL TABLES CHANGED: None
*   FILES READ: None
*   FILES WRITTEN: FILEOUT
*   MODULES CALLED: None
*   CALLING MODULES: A2125 collectdata
*   AUTHOR: Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/
analog_collect()
{
    int K,N,X;                /* counters */

    if(!done) /* do the whole thing */
    {
        mrbufrel(pathnum,bp);
        mrbufget(pathnum,0,&bp);

        /* for(i=0;i<NBUFFITEMS;i++)
           printf("bp [ %d] = %d\n",i,bp[i]); */

        buffptr = 0;

        for (K=0;K<nframes;K+=nchans)
        {
            for (N=0;N<framechans;N++)
            {
                if(dataitem_count[N] >= reduction_count[N]-1)
                {
                    data_scaled = ((float)
                                   (bp[buffptr])/2048.0);

```

```

/* divide by 2048.0 to scale data because MASSCOMP
   automatically in bipolar mode converts a +5v -5v, 10volt
   p-p swing (4096 max) into +- 2048. the offset (.95)
   accounts for margins in the grid plot */

        data_item[N] = mgrscalex((N+3),
                                (.95*data_scaled));

/* ripple this buffer dont worry about graphics accessing
   buffer at same time. The more channels displayed the
   less likely to happen. */

/* pointer method */

        bp2 = &(display_buff[N][0]);
        bp3 = bp2 +1;
        for(i=0;i<DISPPPOINTS - 1;i++)
            *bp2++ = *bp3++;
        display_buff[N][DISPPPOINTS -1] =
            data_item[N];

        dataitem_count[N] = 0;

    }

    else
    {
        dataitem_count[N] = dataitem_count[N]+1;
    } /* end if data_count */

    buffptr = buffptr+1;

} /* end for N< ndispchans */

/* move buffer pointer beyond non-displayed channels
   and skip some frames for data reduction. Use only
   one frame of nchannel frames. i.e have 16 chan per
   frame, use every 16th frame for display */

/* skip over frames for data reduction. Number of frames
   skipped = nchans - 1. Means if have 5 channels per frame
   first frame processed by J loop then skip 4 frames. */

        buffptr = buffptr+(nchans - framechans)
            +(nchans*nchans) - nchans;

/*
        mgrfb(fb,3-fb);
        fb = 3 - fb; */

} /* end for K<nframes */

```



```

/*write buffer to output */
if(write_flag)
    if (write(fout,bp,(NBUFFITEMS*2)) != NBUFFITEMS*2)
    {
        printf("ERROR-can not finish writing to
                output ");
        printf("%s \n",FILEOUT);
        sleep(SN00ZE);
        return;
    }
} /* end analog_collect */

/***** END OF FILE *****/

```

```

/*****
*
*   DATE:      7 October 1985
*   VERSION:   1.2
*   TITLE:    Extract single channel data
*   FILENAME:  extractchan.c
*   OWNER:    BDAS system manager
*   SOFTWARE SYSTEM:  MASSCOMP
*   OPERATING SYSTEM:  Unix version III
*   LANGUAGE:  C
*   USE:      #included in DAADS main module inside file
*             daadsmnu.c
*   CONTENTS:  A22 extractchan, A221 presentextmenu,
*             A222 doextraction
*   FUNCTION:
*   This file contains the Extract menu. It drives the
*   Extract a channel subsystem. This is where the user
*   can extract from a file a single channel and store
*   that channel into a separate specified file .
*
*****/

```

```

/*****
*
*   DATE:      7 October 1985
*   VERSION:   1.2
*   NAME:      extractchan
*   MODULE NUMBER:  A22
*   FUNCTION:   This program is to extract from an already
*               created binary D/A file, a specified
*               channel. After extraction the channel is
*               displayed using graphics routines and then
*               written to a user given output file. The
*               program repeats until user wants to stop.
*
*   INPUTS:    None
*   OUTPUTS:    None
*   GLOBAL VARIABLES USED:  CLEARSC, HITRETURN, TRYAGAIN
*   GLOBAL VARIABLES CHANGED:  None
*   GLOBAL TABLES USED:  None
*   GLOBAL TABLES CHANGED:  None
*   FILES READ:  None
*   FILES WRITTEN:  None
*   MODULES CALLED:  A221 presentextm, A221 doextraction
*   CALLING MODULES:  A2 processmainrequest
*   AUTHOR:  Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

```

```

#define EEXIT '2'

```

```

extractchan()

```

```

{
    char answer[2];
    char temp;

    do /* do the extraction while the answer is not
        EEXIT ('2') */
    {
        printf(CLEARSC);
        presentextractm(); /* present the menu */
        scanf("%s",answer);
        temp = getchar(); /* resets the buffer */
        switch(answer[0])
        {
            case '1' : {

                answer[0] = doextraction();
            }

```

```

        case EEXIT : {
            break;
        }
        default: {
            printf(TRYAGAIN);
            printf(HITRETURN);
            scanf("%c",&temp);
        }
    }
    while (answer[0] !=EEXIT);

    printf("Goodbye\n");
    sleep(SNOOZE);
    return;
} /***** end extractchan *****/

```

```

/*****
*
*   DATE:      7 October 1985
*   VERSION:   1.2
*   NAME:      presentextm
*   MODULE NUMBER:  A221
*   FUNCTION:  Presents the DAADS function header
*   INPUTS:    None
*   OUTPUTS:   None
*   GLOBAL VARIABLES USED:  afit,sysname,extrkmnu,CR
*   GLOBAL VARIABLES CHANGED:  None
*   GLOBAL TABLES USED:  None
*   GLOBAL TABLES CHANGED:  None
*   FILES READ:  None
*   FILES WRITTEN:  None
*   MODULES CALLED:  None
*   CALLING MODULES:  A22 extractchan
*   AUTHOR:  Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

#define qlextract      "1)  Begin extraction\n"
#define q2extract      "2)  Exit to main menu\n"

presentextractm()

(
printf("                ");
printf(afit);
printf("                ");
printf(sysname);
printf("                ");
printf(extrkmnu);
printf(CR);
printf(CR);
printf("Please examine the menu below and indicate the type
                        of operation\n");
printf("you wish to perform. \n");
printf(CR);
printf(" Extract Single Channel Menu:  \n");
printf(CR);
printf(qlextract);
printf(q2extract);
printf(CR);
printf(CR);
printf(CR);
printf("Please indicate choice by typing in corresponding
                        number above:  ");

) /***** end presentextractm *****/

```

```

/*****
*
*
*   DATE:      7 October 1985
*   VERSION:   1.2
*   NAME:      doextraction
*   MODULE NUMBER:  A222
*   FUNCTION:   Separates from an existing binary
*               multi-channel file a single channel of
*               data. Writes to a file the separated
*               data. User choses to display data during
*               extraction or just extract.
*
*   INPUTS:    None
*   OUTPUTS:   None
*   GLOBAL VARIABLES USED: None
*   GLOBAL VARIABLES CHANGED: None
*   GLOBAL TABLES USED: None
*   GLOBAL TABLES CHANGED: None
*   FILES READ: Binary file containing multi-channel data
*   FILES WRITTEN: Binary file containing single channel
*                 data
*   MODULES CALLED: None
*   CALLING MODULES: A22 extractchan
*   AUTHOR:    Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

```

```

int doextraction()
{
#define FLBUFSIZE  600
#define BUFSIZE    600
#define MAXCHANNELS 16
#define MINUSONE   (-1)
#define BLANKS     "      "
int fcount = 100;
int dispcount;

float xarray[100] ;
float yarray[BUFSIZE] ;
float *adyarray;
double x,fx,y;
double rbuffsize;
short datamask;

int xl,yt,xr,yb,null;
int fb,channum,DONE;

```

```

char data_in_file[30],data_out_file[30];
short int gpbuff[BUFFSIZE], writebuff[BUFFSIZE];
int nchan;
static short filebuf[FLBUFSIZE * MAXCHANNELS];
int c;
int ENDFILE = 0;
int bufferflag;

char anschar[2];
int j,i;
int modeflag; /* to tell if parallel (1) or analog (2) */
int first = 1; /* if first time in program or not */
float m;
int count, count2;
int vunum = 2;

int fpin,fpout; /* for use with read and write */
int n_bytes,data_items;

/***** begin doextraction *****/

/* Initialize graphics, files, how many channels per how
   many frames */

DONE = 0; /* flag to let user quit */

/* get info from user */

printf("\033E\n");
printf("\033[2J\n");
printf("Before continuing I need some information
      from you.\n\n");
printf("This program reads from an EXISTING binary file,
      displays a \n");
printf("selected channel, then writes that channel
      information to a \n");
printf("given output file. ");

      mgiasngp(0,0);
      mgigetvcoord(2,&x1,&yb,&xn,&yt,&null); /* get window
                                             coordinates for scaling */
      mgigpneq(1,0);
      mgidefw(3);
      mgipw(3,2,x1,yb,xn,yt);
      mgrvcoord(3,0,0,-1,0,1,0,1,0);

while(DONE == 0)

```

```
(
/* this user information is inside a loop because it is
needed for every extraction */
```

```
printf(" I need from you the following: \n\n");
do
{
printf("      The number of channels originally
      collected (nchan):  ");
printf("      (Refer to the session or setup file if
      not sure.)");
scanf("%d",&nchan);
if(nchan <= 0 || nchan > MAXCHANNELS) /* if an
      invalid response is given */
printf("\nIllegal value; the number of channels must
      be between 0 and %d inclusive.\n",nchan);
}
while(nchan <= 0 || nchan > MAXCHANNELS);
do /*keep looping until a valid response is given*/
{
printf("      The channel number to extract
      (00 . . . nchan):  ");
printf("      Refer to the channel order file if not
      sure. ");
scanf("%d",&channum);
if(channum < 0 || > nchan);
printf("\nIllegal value; the channel number must
      be between 00 and %d inclusive.\n",nchan);
}
while(channum <= 0 || channum > nchan) ;

if(!first) /* 2nd or more time through program */
{
do /* keep looping until valid response (y or n) */
{
printf(" \nIs input file the same? y or n ");
scanf("%s",anschar);
if(anschar[0] != 'y' && anschar[0] != 'n')
printf("\nIllegal response; answer 'y' or 'n'
      (lower case).");
}
while(anschar[0] != 'y' && anschar[0] != 'n');
}
```



```

if(first || anschar[0] == '\n') /* first time in this
    program, or a different input file */

{
printf(" Please give the EXISTING binary input
                                file name:  ");
scanf("%s",data_in_file);
first = 0;
}
fpin = open(data_in_file,0); /* 0 - reads */
if(fpin == MINUSONE)
{
    printf("Error in opening %s . \n",
                                data_in_file);
    mgideapp();
    return(1); /* return to extract menu*/
}

printf("\n Please give the output file name:  ");
scanf("%s",data_out_file);

if((fpout = open(data_out_file,1)) == -1)

fpout = creat(data_out_file,0766); /* create the
                                data output file */

if(fpout == MINUSONE)
{
    printf("Error in opening %s . \n",
                                data_out_file);
    mgideapp();
    return(1);
}

do
{
    printf("\n Is the input collected as parallel
            (digital) (1) or analog(2)");
    scanf("%d",&modeflag);
}
while(modeflag <1 || modeflag >2);

if(modeflag == 1)
datamask = 0x0fff; /* parallel, strips off channel
                                header 10 */
else
datamask = 0xffff;

```

```

/* init graphics */

mgipln(-1); /* enable all planes */
mgifb(1,3);
mgiclearpln(2,-1,0);
mgihue(3);

mgipln(1);
mgiv(3);

mgrl(.05,-.95,.05,.95);
mgrl(.05,0.0,.95,0.0);

for (m= -.95;m<0.0;m=m+.19)
    mgrl(.05,m,.06,m);
for (m= 0.0;m<.96;m=m+.19)
    mgrl(.05,m,.06,m);

mgipln(2); /* disables the first plane to all
                                                    changes */

x = 0.05;
nbufsize =BUFSIZE * 1.0; /*to make bufsize real*/
fx = (6.0/nbufsize);
for(j=0;j<fcount;j=j++)
{
    xarray[j] = x;
    /*mgrscalex(3,x); */
    x = x + fx;
}

fb = 1;

mgifb(fb,3-fb);
fb = 3-fb;

while((n bytes =read(fpin,filebuf,(FLBUFSIZE*nchan*2))) > 0)

/* do the extraction, graphics and writing */
{
    count2 = n bytes/2;

```

```

/* extract the channel from the file buffer */

    if(count2 > 600)
        count2 = count2/nchan; /* do only 600 max
                                for graphics or do up
                                to what ever count2 is */

    for(count=0;count< count2;count++)
    {
        writebuff[count] = filebuf[(count*nchan)+channum];
        gpbuff[count] = writebuff[count] & datamask;

        y = ((float)(gpbuff[count]))/4095;
        yarray[count] = y ;
    }
/* count now contains the number of items in the
   graphics buffer count is <= 600 will scale only the
   number of points obtained. except for last of file
   this number should be 600. */

for(adyarray = yarray,dispcount=0;
(adyarray < &yarray[BUFSIZE-fcount-1]) ;
    adyarray +=20,dispcount+=20)

{

    while(bufferflag != 0) ;
    bufferflag = 1;

    mgrls(fcount,xarray,adyarray);
    mqi fb(fb,3-fb);
    fb = 3 - fb;
    mgiclearpln(2,2,0);
    mgaaol(18,mgfadd(&bufferflag));

}

/* write writebuff to the data_out_file */

    write(fpout,writebuff,(BUFSIZE * 2));

} /* end while not ENDFILE */

```

```

/* close the files */

close(fpin);
close(fpout);

ENDFILE = 0; /* RESET THE END OF FILE MARKER */
mgiclearpln(2,-1,0);

printf("Would you like to do another chan ???
                                     1 = Y or 2 = N \n\n ");
scanf("%d",&j);
    if(j == 2) /* !! ( j == "N") */
        DONE = 1;
    else
        DONE = 0; /* dont stop */

    printf("\033E\n");
} /* end while not DONE */

    mgifb(1,3);

    mgiclearpln(2,-1,0);
    mgideagp();

    return(2); /* normal return value to to
                exit menu also */

} /****** end doextraction *****/

/***** END OF FILE *****/

```

```

/*****
*
*   DATE:      7 Oct 1985
*   VERSION:   1.2
*   TITLE:    Replay collection session
*   FILENAME:  replay.c
*   OWNER:    BDAS system manager
*   SOFTWARE SYSTEM:  MASSCOMP
*   OPERATING SYSTEM:  Unix version III
*   LANGUAGE:  C
*   USE:      #included in DAADS main module inside file
*             daadsmnu.c
*   CONTENTS:  para_display, analog_display
*   FUNCTION:  This file contains the menu to drive
*             the Replay subsystem. This system will
*             allow the user to replay data previously
*             stored to the graphics monitor.
*
*****/

```

```

/*****
*   DATE:      7 Oct 1985
*   VERSION:   1.2
*   NAME:      replay
*   MODULE NUMBER:  A23
*   FUNCTION:
*   INPUTS:    None
*   OUTPUTS:   None
*   GLOBAL VARIABLES USED:  CLEARSC, HITRETURN, TRYAGAIN
*   GLOBAL VARIABLES CHANGED:  None
*   GLOBAL TABLES USED:    None
*   GLOBAL TABLES CHANGED:  None
*   FILES READ:  None
*   FILES WRITTEN:  None
*   MODULES CALLED:
*   CALLING MODULES:  A2 processmainrequest
*   AUTHOR:  Capt Douglas G. Fitzpatrick
*   HISTORY:  This file was copied from Fitzpatrick's
*             "Thesis Catalog Backup - 12 Dec 84" floppy
*             disk by Capt Jarvis on 26 Sep 85 and
*             implemented in the DAADS program
*****/
#define REXIT '2'
replay()
(
    char answer[2];
    char temp;
    do
    (
        printf(CLEARSC);
        presentreplaym();
        scanf("%s",answer);
        temp = getchar();
        switch(answer[0])
        (
            case '1' : (
                answer[0] = doneplay();
            )
            case REXIT : (
                break;
            )
            default: (
                printf(TRYAGAIN);
                printf(HITRETURN);
                scanf("%c",&temp);
            )
        )
    )
    while (answer[0] !=REXIT);
    printf("Goodbye\n");
    sleep(SNOOZE);
    return;
) /* end replay */

```

```

/*****
*
*   DATE:      7 Oct 1985
*   VERSION:   1.2
*   NAME:      presentreplaym
*   MODULE NUMBER:  A231
*   FUNCTION:   Presents the DAADS function header
*   INPUTS:     None
*   OUTPUTS:    None
*   GLOBAL VARIABLES USED:  afit,sysname,replaymnu,CR
*   GLOBAL VARIABLES CHANGED:  None
*   GLOBAL TABLES USED:  None
*   GLOBAL TABLES CHANGED:  None
*   FILES READ:  None
*   FILES WRITTEN:  None
*   MODULES CALLED:  None
*   CALLING MODULES:  A23 replay
*   AUTHOR:   Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/

```

```

#define q1replay      "1)  Begin replay\n"
#define q2replay      "2)  Exit to main menu\n"

```

```

presentreplaym()

```

```

{
printf("                ");
printf(afit);
printf("                ");
printf(sysname);
printf("                ");
printf(replaymnu);
printf(CR);
printf(CR);
printf("Please examine the menu below and indicate the\n");
printf("type of operation you wish to perform. \n");
printf(CR);
printf(" Replay previous collection Menu:  \n");
printf(CR);
printf(q1replay);
printf(q2replay);
printf(CR);
printf(CR);
printf(CR);
printf("Please indicate choice by typing in ");
printf("corresponding number above:  ");
} /* end presentreplaym */

```

```

/*****
*
*   DATE:      7 Oct 1985
*   VERSION:   1.2
*   NAME:      doneplay
*   MODULE NUMBER:  A232
*   FUNCTION:   Replays off-line, biophysical data
*               previously collected.
*   INPUTS:    None
*   OUTPUTS:   None
*   GLOBAL VARIABLES USED:  None
*   GLOBAL VARIABLES CHANGED:  None
*   GLOBAL TABLES USED:    None
*   GLOBAL TABLES CHANGED:  None
*   FILES READ:  Binary file containing multi-channel data
*   FILES WRITTEN:  None
*   MODULES CALLED:  A2123 initgraphics, showparameters,
*                   A2321 par_display, A2322 analog_display, round
*   CALLING MODULES:  A23 Replay
*   AUTHOR:   Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/
int doneplay()
{
#define BUFFSIZE 215
int nchans;
int ndata_flag;
int ndispchans;
char rchanodr[30];
char rfilein[30];
int chanorder[16];
int NBUFFITEMS;
int nframes;
int calcsz = 192;
int n_bytes;

short inbuff[BUFFSIZE];
double rframes;
int fd,fdinfile;

FILE *fpssession,*fopen();
char session_file[30];
char tempchar;
int framechans;
int parameterok;

```



```

/* ***** begin replay ***** */

/* get session header file name */

do
{
printf(CLEARSC);
printf("Please give the Session Header file name\n");
scanf("%s",session_file);
tempchar = getchar();
printf("Looking for  %s  \n",session_file);
sleep(SNOOZE);

if((fd = open(session_file,0)) == MINUSONE )
{
printf("Session header file  %s does not exist.\n",
      session_file);
printf(HITRETURN);
scanf("%c",&tempchar);
return(1);
}
else /* read the session header file */
{
close(session_file);
fpsession = fopen(session_file,"r"); /* use
                                     fopen so can use fscanf */
fscanf(fpsession,"%d %d %d %s %s",&ndata_flag,
      &rnchans,&rndispchans,rchanodr,rfilein);

parameterok = showparameters(ndata_flag,rnchans,
      rndispchans,rchanodr,rfilein,session_file);
/* note: showparameters is defined in A2122
      interactive_setup */
}
}
while(parameterok != 1);

/*check for file existence - input file,channelorder file*/

/* calculate the number of buffitems */

nframes = (float)calcsz/(float)rnchans;
nframes = round(nframes);
nframes = (nframes % 2) ? nframes + 1 : nframes;

NBUFFITEMS = nframes * rnchans;

```

```

/* open input file */

if((fdinfile = open(rfilein,0)) == MINUSONE)
{
    printf("\nInput file %s does not exist ",rfilein);
    printf(HITRETURN);
    scanf("%c",&tempchar);
    return(1);
}
else
    /* read file , do replay */

    (
        initgraphics(rnchans,rndispchans,rchanodr,chanorder);

/* when only have one channel need to adjust display to
think it has two channels, this is to keep a clean display,
else the display buffers are accessed too quickly by the
graphics processor and a weird display results */

        if(rnchans == 1)
        {
            nframes = 96;
            rnchans = 2;
            framechans = 1;
        }
        else
            framechans = rndispchans;

        while((n_bytes = read(fdinfile,inbuff,
                               (NBUFFITEMS * 2))) > 0 )

        {
            if(rdata_flag == 1)
                para_display(inbuff,rnchans,
                             rndispchans,nframes,framechans);
            else
                analog_display(inbuff,rnchans,
                               rndispchans,nframes,framechans);

        }
    ) /* end else */

/* stop graphics, close infile */
mgihaltdisp(3);
mgiseg(end_list);
mglwseg(end_list);
for(i=0;i<16;i++)
    dataitem_count[i] = 0;
close(+tdinfile);
mideaq(0,0);
} /***** end do replay *****/

```

```

/*****
*
*   DATE:      7 Oct 1985
*   VERSION:   1.2
*   NAME:      para_display
*   MODULE NUMBER: A232
*   FUNCTION:  Process the collected parallel data.
*               Separates channels into display buffers while
*               doing data reduction (1/rchans). Scales data
*               for display
*   INPUTS:    inbuff,rchans,rndispchans,nframes,
*               framechans
*   OUTPUTS:   None
*   GLOBAL VARIABLES USED: NBUFFITEMS, DISPOINTS
*   GLOBAL VARIABLES CHANGED: None
*   GLOBAL TABLES USED: None
*   GLOBAL TABLES CHANGED: None
*   FILES READ: None
*   FILES WRITTEN:
*   MODULES CALLED: None
*   CALLING MODULES: A23 replay
*   AUTHOR:    Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/
para_display(inbuff,rchans,rndispchans,nframes,framechans)

```

```

short inbuff[];
int rchans,rndispchans,nframes,framechans;
{
    int J,m,K;
    short data_temp;
    unsigned short channum;
    double data_scaled;
    short int data_item[12];
    int buffptr;
    int *nbp2,*nbp3;
    char stopchar[2];

    buffptr = 0;
    for (K=0;K<nframes;K+=rchans)
    {
        for (J=0; J < framechans : J++)
        {
            channum = inbuff[buffptr] & 0xf000; /* mask
            with an int 2 byte long value */

            channum = (channum >> 12);
            m = channum;
            if (m < rndispchans)

```

```

/* scale data and place in data_item for placement with
   display_buff */
{
    if(dataitem_count[m] >= reduction_count[m]-1)
    {
        data_temp = inbuff[buffptr] & 0x0fff;
        data_temp = 2048 - data_temp;
        data_scaled = ((float)(data_temp)
                       /2048.0);
/* parallel in from CIM is unipolar from 0 - 4096 values,
   2048 minus chain input brings input between -2048 and
   +2048 then divide by 2048.0 to scale data into the
   display window set at a relative -1.0 to +1.0 in y-plot
   values. The offset of .95 accounts for margins in the
   grid plot */
        data_item[m] = mgrscalex((m+3),
                                  (.95*data_scaled));
/* Ripple this buffer dont worry about graphics accessing
   the buffer at the same time. The more channels
   displayed, the less likely this is to happen. */
        rbp2 = display_buff[m];
        rbp3 = rbp2 +1;
        for(i = 0; i < DISPPPOINTS-1; i++)
        {
            *rbp2++= *rbp3++;
        }
        display_buff[m][DISPPPOINTS - 1] =
            data_item[m];
        dataitem_count[m] = 0;
    }
    else
    {
        {
            dataitem_count[m] = dataitem_count[m] +1;
        } /* end if data_count */
    } /* end if m< rndispchans */

buffptr = buffptr + 1;
} /* end for J */

/* Skip over frames for data reduction. Number
   of frames skipped = nchans - 1. Means if have
   5 channels per frame, first frame processed by

} /* end for K */
} /* end par_display */

```

```

/*****
*
*   DATE:      7 Oct 1985
*   VERSION:   1.2
*   NAME:      analog_display
*   MODULE NUMBER:  A2322
*   FUNCTION:   Process collected analog data.  Separates
*               channels into individual display buffers
*               while doing data reduction of (1/nchans).
*               Scales data to fit into the display
*               window.
*   INPUTS:    inbuff,nchans,rndispchans,nframes,framechans*
*   OUTPUTS:   None
*   GLOBAL VARIABLES USED:  NBUFFITEMS, display_buff
*   GLOBAL VARIABLES CHANGED: None
*   GLOBAL TABLES USED:   None
*   GLOBAL TABLES CHANGED: None
*   FILES READ:  None
*   FILES WRITTEN:  FILEOUT
*   MODULES CALLED:  None
*   CALLING MODULES:  A23 rejplay
*   AUTHOR:   Capt Douglas G. Fitzpatrick
*   HISTORY:
*
*****/
analog_display(inbuff,nchans,rndispchans,nframes,framechans)

```

```

int nchans,rndispchans,nframes,framechans;
short inbuff[];

{
double data_scaled;
short int data_item[12];
int buffptr;
int *nbp2,*nbp3;
char stopchar[2];
int K,N,X;           /* counters */

    buffptr = 0;

    for (K=0;K<nframes;K+=nchans)
    {
        for (N=0;N<framechans;N++)
        {
            if(data_item_count[N] >= reduction_count[N]-1)
            {
                data_scaled = ((float)(inbuff[buffptr])
                               /2048.0);
            }
        }
    }
}

```

```

/* divide by 2048.0 to scale data because MASSCOMP auto-
   matically in bipolar mode converts a +5v -5v, 10volt
   p-p swing (4096 max) into +- 2048. The offset (0.95)
   accounts for margins in the grid plot */

      data_item[N] = mgrscalev((N+3),
                              (.95*data_scaled));

/* ripple this buffer dont worry about graphics accessing
   the buffer at the same time. The more channels
   displayed, the less likely this is to happen. */

/* pointer method */

      rbp2 = &(display_buff[N][0]);
      rbp3 = rbp2 + 1;
      for(i=0; i<(DISPPPOINTS - 1); i++)
          *rbp2++ = *rbp3++;
      display_buff[N][DISPPPOINTS - 1] =
          data_item[N];

      dataitem_count[N] = 0;
    }
  else
  {
      dataitem_count[N] = dataitem_count[N]+1;
  } /* end if data count */

  buffptr = buffptr+1;

} /* end for N< ndispchans */

/* move buffer pointer beyond non-displayed channels
   and skip some frames for data reduction. Use only
   one frame of nchannel frames. i.e have 16 chan per
   frame, use every 16th frame for display */
/* skip over frames for data reduction. Number of frames
   skipped = nchans-1. Means if have 5 channels per frame
   first frame processed by J loop then skip 4 frames. */

      buffptr = buffptr+(nchans - framechans)
          +(nchans*nchans) - nchans;

} /* end for K<nframes */

} /* end analog_display */
/***** END OF FILE *****/

```

```

/***** data_analysis *****/
/*****
*
*   This program has not been written yet.  It will
*   be defined by the needs of the user.  It probably
*   should contain a smoothing function to make the
*   data more manageable for computer analysis.  A
*   skeleton program has been developed and is available
*   to follow-on researchers and thesis students.
*
*****/

```

```

/*****
 *
 * This file contains the global declarations
 * and defines that are needed for the Data
 * Acquisition and Display System(DAADS).
 *
 *****/

#include <stdio.h>

/* cursor control characters for the h19 */

#define CLEARSC "\033E"

/* defines used by most all menus */

#define MEXIT 5
#define CR "\n"
#define NOTREADY "This option is not available at this\n\ntime\n"
#define TRYANOTHER "Please try another option\n"
#define TRYAGAIN "Incorrect response, please try again\n"
#define HITRETURN "please hit return when ready\n"
#define afit "Air Force Institute of Technology\n"
#define sysname "Data Acquisition and Display System\n"
#define mainmnu "Main Menu Module\n"
#define dacmnu "Data Acquisition and Display Module\n"
#define changmnu "Change Channel Order Module\n"
#define replymnu "Replay Session Module\n"
#define extrkmnu "Extract Single Channel Module\n"
#define SNOOZE 2
#define exitmnu "5) Exit menu\n"

```



```

/*  this goes with the data acquisition routines  */

#define      EXREAD      1
#define      EXWRITE     0
#define      NBUFFERS    90
#define      BUFFSIZE    192

short acqbuff[NBUFFERS][BUFFSIZE];
short pinmask = 0xffff;
short *bp;
int chanorder[16];
char chanlabel[16][255];
int nchans;
int data_flag;
static int pathnum = -1;
#define MAXWINDOWS 12

intndispchans;
int NBUFFITEMS;
int nframes;

double realxl = 0.0;
double realyb = 0.0;
double realxr = 100.0;
double realyt = 2.0;
#define FREQ1CLK 160.0
#define FREQ2CLK 10000.0

#define DISPBUFSIZE 95
#define NDISPBUFFS MAXWINDOWS

int display_buff[NDISPBUFFS][DISPBUFSIZE] = {0};
int xarray[95] = 0;
int display_flag[NDISPBUFFS] = 0;
static int mainseg[1000];
static int displayit[1000];

int DISPOINTS = 95;
short offset;

/***** END OF FILE *****/

```

```

/*****
*
*   This is a sample channel order file where the
*   first column of numbers is the channel number,
*   the second column is the secondary reduction
*   factor, and the third column is the display
*   window channel identification label.
*
*****/

```

```

00 0010 EKG
01 0010 Temp
02 0005 ENG (H)
03 0005 ENG (V)
04 0001 GSR
05 0010 Photo Plethys (finger)
06 0001 EGG
07 0001 EIG
08 0001 Photo Plethys (facial)
09 0001 Pneumograph (chest)
10 0001 Pneumograph (waist)
11 0001 Ballistocardiogram
12 0001 EMG
13 0001 EEG (int)
14 0001
15 0001

```

```

/***** END OF FILE *****/

```

```

/*****
*
*   This is a sample set-up file as described
*   in the Fitzpatrick, Williams, and Rogers
*   thesis. The following format should be
*   followed exactly. Note that when a setup
*   file is created interactively in the DAADS
*   program, it is not in this format. Thus
*   an interactively created set-up file can
*   not be used directly for a new data
*   collection session.
*
*****/

```

```

14          /* # of collected channels */
08          /* # of displayed channels */
02          /* collection mode          */
session(date) /* session file name      */
(date)bindata /* binary output data file */
chanelorder  /* channel order file name */

```

```

/*****
 *
 *   This is a short program written for BDAS to be used *
 *   used as a round-off function. It is used in      *
 *   several modules (initda.c, doneplay). It is      *
 *   listed here for completeness.                  *
 *
 *****/

#include <math.h>

round(x)
float x;
{
    int value;
    float value2;

    value2= ((float) ceil(x) - x);
#ifdef DEBUG
    printf("value of ceil(%f) - %f =%f\n",x,x,value2);
printf("value of floor(%f) = %d\n",x,value);
#endif

    if( ((value = ceil(x)) - x) < 0.5000)
        return(value);
    else
        return((value=floor(x)));
}

```

## VITA

Norman Richard Jarvis was born the son of Franklin Thompson and Mary Berrio Jarvis on 28 October 1952 in Newton, Massachusetts. He graduated with honors from North Reading High School, North Reading, Massachusetts in June 1970. He received a Bachelor of Science degree in Zoology from the University of Massachusetts, Amherst in June 1974 and an Emergency Medical Technician-Ambulance certification from Symmes Hospital, Arlington, Massachusetts in January 1975. After ambulance work in Boston and biomedical research work at the Marine Biological Research Laboratories, Woods Hole, Massachusetts, he entered the Air Force and was commissioned from Officer Training School in May 1979. Upon completion of Space Systems Operations training at Peterson AFB, Colorado, he was assigned to the Cavalier Missile Early Warning Station at Concrete, North Dakota as a Space Systems Director. He was subsequently assigned to Headquarters NORAD/Space Command as a Missile Warning Systems Staff Officer before entering the Air Force Institute of Technology in June 1984.

Permanent Address: 185 North Street

North Reading, Massachusetts 01864

## VITA

Captain Charles T. Uyeda, Jr., was born on 13 March 1958 in San Francisco, California, to Dr. Charles Tsuneo Uyeda and the former Sumi Maeda. "Bud" Uyeda graduated as Valedictorian from Awalt High School in Mountain View, California, in 1976. After graduation, he entered the United States Air Force Academy, Colorado Springs, Colorado, from which he received his USAF commission and the degree of Bachelor of Science in Biology in May 1980. After attending the Space Systems Operations training school at Peterson AFB, Colorado, he was assigned to the Air Force Satellite Control Facility/VOC, Sunnyvale AFS, California. He served at Sunnyvale AFS as an Operations Director until entering the School of Engineering, Air Force Institute of Technology, in June 1984.

Permanent Address: 2540 Fairbrook Drive  
Mountain View, California 94040

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→ A computerized biophysical data acquisition system was refined and used to collect biophysical data on human volunteer subjects to examine effects of coriolis induced motion sickness. Redesigned sensors to measure electrical cardiac activity, cardiac chest rebound, abdominal/thoracic respiration, peripheral pulse blood volume, facial pulse blood volume, skin temperature, gastric/intestinal activity, nystagmus, and brain wave activity were incorporated with commercially available sensors for galvanic skin response, heart rate, and blood pressure to thoroughly measure the subject's vital signs.

Subjects were rotated in a multi-axis motion chair and data collected for later analysis. Data were collected on paper strip chart recorders in parallel with a MASSCOMP MC500 minicomputer. The MASSCOMP data acquisition system software was refined with better documentation and to allow data replay. *Keywords:*

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